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OBSERVATIONS

ON

METALLIFEROUS DEPOSITS,

AND ON

SUBTERRANEAN TEMPERATURE;

FORMING THE EIGHTH VOLUME OF THE TRANSACTIONS OF THE ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

PART THE FIRST.

BY

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SOMETIME HER MAJESTY'S ASSAY-MASTER OF TIN IN THE DUCHY OF CORNWALL.

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Observations on Metalliferous Deposits. By William Jory Henwood, F.R.S.; F.G.S.; Member of the Geological Society of France; President of the Royal Institution of Cornwall; Honorary Member of the Yorkshire Philosophical Society; Corresponding Member of the Imperial Agricultural and Natural History Society—Lyons, and of the Lyceum of Natural History—New York; sometime Her Majesty's Assay-Master of Tin in the Duchy of Cornwall; Member of the Society.

NORTH-WESTERN INDIA.

Kumaon and Gurhwal.—The granite of Dwarra Hath, Almora, and Deo Dhoora—although surrounded by metalliferous rocks—is, itself, barren. The micaceous, talcose, and chloritic slates are interlaid—by various ores of copper (I.) at *Kurrye* (*a.*), *Rai* and *Bellar* (*b.*), *Goron* (*c.*), *Seera* (*d.*), *Pokree* (*e, f, g, h.*), and *Al Agur* (*i.*); —and with iron-ores (II.) at *Sahloo* (*a.*), *Agur* (*b.*), *Luttea Garh* (*c.*), *Bunna* (*d.*), *Shealgarh*, *Guarcoolee*, *Lusghanee*, *Nutoa Kanh*, *Gallà*, *Dhoora Kanhi*, *Capuà*, *Choocootà*, *Bunnà*, *Purturburà*, &c., (*e.*). The talcose and clay-slates, at and near their union, include conformable beds charged with copper-ore, at *Seera* (*d.*), and *Pokree* (*g.*). The clay-slates of *Pahlee* (*f.*), *Pahlee* in Kalee Kumaon (*g.*), *Mungla Lekh* (*h.*), *Tilpoorà* and *Simul Khet* (*i.*), contain similar deposits of iron-ore; and in the same series graphite is obtained at Dol. Clay-slate and calcareo-siliceous breccia are separated by a band of iron-ore at *Burrulgaon* (*i.*); and the same breccia, together with a calcareo-siliceous conglomerate by which it is succeeded, are overlaid by similar iron-ore at *Rampoore* (*i*). At *Khuloa-garh* and *Hurchinolee* (*j.*) calcareous slates are charged, and at *Tutyl* (*k.*) they alternate, with iron-ore. In the calciferous slate and siliceous limestone of *Dhunpoore* (*j.*) the ores of copper are mostly determined to the joints. Calcareo-siliceous rocks are impregnated with copper-ore at *Tarag-ke-tal* (*k.*) and with the ores of iron at *Oojowlee* (*m.*), *Kyrolee* and *Patol* (*n.*). The quartz-rocks which prevail near the junction of the Khurna with the Kosila (*l.*) are largely associated with iron-ore; and siliceo-ferruginous conglomerates appear at *Jham*, *Bejapoore*, *Loha Bhabur*, and Dechowree. Limestone is overlaid by sandstone at

Bhamouree. Beds of pebbles and gravel occur, far above the reach of neighbouring streams near Dwarra Hath and Nehal-bridge. In similar, though in thicker, deposits on the low grounds, many small rivers disappear; after considerable courses beneath the *detritus*, however, they reappear at the surface. Siliceous sand and granitic gravel are slightly mixed with gold in the beds of the Ramgunga, the Aluknunda, and the Pindur. The operations of native miners in the Himalaya are in the last degree rude, ineffiective, and costly; fire is applied to the rocks to aid the operations of the workmen, and torches of resinous wood are used to light them at their labours. Attempts to introduce systematic mining have been made by the Government, but without success. The furnaces, bellows, and other appliances of the native iron-smelters are, beyond measure, rude and inefficient; moreover their charcoal—made of the softest wood—is inadequate to producing the requisite heat. Both the produce and the refuse of the furnaces are divided in recognised proportions amongst the Farmer of the revenue, the Miner, the Smelter, and the Charcoal-burner. The Government revenue from the mines has varied from about three hundred and sixty to five hundred Pounds a year. Many of the inhabitants migrate as the seasons change; and thus those who cultivate the plains at one period of the year, work mines and smelt ores in the hills at another. 1—63.

Bengal. The gneiss of the Rajmahal is succeeded by quartz rocks at Fitcooree (*a.*), and these by siliceous sandstone containing carbonaceous matter and nodules of iron-ore at Jherria. Masses of conglomerate and of amygdaloidal trap overlie the sandstone and a seam of coal crops out in the same neighbourhood. Iron-ore occurs both in nodules and in the joints of sandstones near Taldanga; and on the opposite side of the Barrukkar thin layers of similar ores interlie a body of shale (*b.*). At Akysá and Barrul Cajoor rocks and ores of much the same characters are overlaid by a bed of coal, which has been opened in several places (*c*, *d*, *e.*). Both at Jherria and Barrul Cajoor heaps of slag show that iron-ore was formerly smelted in the neighbourhood. 64—8.

CHILI.

Chañarcillo. The isolated mountain of Chañarcillo which rises nearly four thousand feet above the Pacific and more than two

thousand higher than the surrounding country, consists of three calcareous (*a*, *c*, *e*.), alternating with two felspathic, quartzose, and hornblendic (*b*, *d*.), strata. They all decline towards the south-west, but at somewhat different angles; and in various parts of the district they differ materially in thickness. Several beds in each of the strata are characterized by diversities of colour, composition, and structure. All five formations are traversed—but without displacement—by two narrow dykes of felspar, hornblende, and quartz. The entire series is intersected by many *lodes* and *branches*, of which the greater number bear 18°–45° E. of N.—W. of S., others, however, range nearly at right-angles to them; but all, without exception, dip oppositely to the strata. The earthy ingredients of the *lodes* are much the same as those of immediately adjoining portions of the rocks; and their metallic contents undergo a corresponding change as they pass from one formation to another. Native silver abounds not only in many calcareous parts of most *lodes*, but, for considerable distances beyond their *walls*, it is disseminated through (the *Manto de Ossa*) certain upper layers of the first limestone, and fills, or faces, their joints. Several of the ores of silver are disposed in much the same manner, yet, perhaps, scarcely to the same extent. But notwithstanding the *lodes* contain silver and several of its ores in the three limestones, their riches and the various ores they afford are by no means equally determined to every part of each stratum. Both the metallic minerals and the vein-stones, however, maintain the same endlong *(shoot)* dip in every *lode* and in all the limestones; moreover the richest parts of different *lodes* often occur on the same meridians. in the first limestone, portions of the *Candelaria lode* afforded virgin metal and ore of various kinds which yielded nine hundred *(Troy)* lbs. of silver per *(Avoir.)* ton; and in the second limestone sixteen hundred tons of ore from the *Colorada lode* gave sixty-four thousand lbs. of metal, one-eighth of which was extracted by two miners in a month, A part of *Waring's lode* was so intertwined with native silver that—too tough for extraction with ordinary tools, and too porous to be blasted—it was cut out, bit by bit, with chisels. In 1855–6 the various ores of *Colorada* yielded—by smelting—from 0·00279 to 0·00367 and by amalgamation from 0 01172 to 0·01426 their weight of silver, a proportion much smaller than that of earlier years. In little more than a quarter of a century the produce of Chañarcillo amounted to more than six millions Sterling. Between

the several calcareous strata (*a*, *c*, *e*.) the *lodes*—maintaining their normal directions anddips—partake the felspathic, quartzose, and hornblendic characters of the strata (*b*, *d*) which intervene, but they then afford traces of blende and small quantities of iron-pyrites only. Several unproductive (*cross-*) veins, which traverse the district, differ materially from most, yet nearly coincide with some, of the *lodes* in direction, and—like the *lodes* in general—they dip oppositely to the strata, but in some measure conform to the endlong *(shoot)* dip of the ore ; their ingredients—calcareous in some, but felspathic, quartzose, and hornblendic in other, places —closely resemble those of the immediately contiguous rocks ; and they are divided lengthwise by numerous joints, of which the opposite faces are often deeply scored with unconformable striæ. On passing from the cellular limestone of the *Manto de Ossa* into the compact rock beneath, the *lodes*—diverging from their normal dip and inclining at a much lower angle—take their way for some distance between the two, but ultimately they resume their ordinary inclination. The several interferences of *lodes* are —even in the same neighbourhood—attended by inosculations, by simple intersections, and by *(heaves)* displacements. Hitherto the *Colorada* is the only *lode* ascertained to cut a *cross-vein ;* and this through an inconsiderable vertical range. In all their interferences with *cross-veins*, however, the *lodes* are *(heaved)* displaced, longer or shorter distances, towards the *left-hand*, and to the side of the greater angle (L.—G. A.). Neither of the *lodes*, and one only of the *cross-veins*, interferes with the levels of the rocks in its opposite sides *(walls)*. In the exceptional case, of the *flucan* at *San Francisco viejo*, the several strata which form its upper *(hanging-wall)* side are many fathoms below their respective counterparts in the lower *(foot-wall)* ; the *lodes* suffering, at the same time, corresponding displacements. Evidence yet exists that the surface of Chañarcillo was once watered ; and that through the valley of Copiapò a river formerly flowed to the ocean ; now, however, a perpetual drought prevails at the former ; and—even when snow melts on the Cordillera—pools only appear at intervals in lower parts of the latter. This disappearance of water has been concurrent with the destruction of forests in the neighbourhood. The absence of water in the mines is as remarkable as it is at the surface of Chañarcillo; for mines have been opened to, and wrought at, a depth of more than two hundred and sixty fathoms without the aid of pumping-machinery, or, in fact, without the

appearance of water. But if this absolute drought be beneficial in some, it is at least as prejudicial in other, respects; as it deprives the miner of cheap means for extracting his ores and separating them from the vein-stones. The ignorance and prejudice of the native mine-owner prohibits use of the wheel-barrow, the windlass, and the *(kibble)* bucket, all ore and rubbish are taken within the reach of horse-power, or to the surface, on the backs of labourers. Owing to these exceptional circumstances, and to the enormous cost of food and drink, much ore, which might have been wrought to advantage, now remains unbroken in the mine, and *undressed* at the surface. All necessaries of life, both for the people and for the animals they employ, are brought, on beasts of burthen, from considerable distances; of the water, indeed, small quantities only are drinkable; the rest — like that in the river of Copiapò—containing salts of soda in large proportions. The only water used in locomotive boilers on the Copiapò railway is, in fact, obtained by distillation of sea-water at Caldera and of river-water at Piedra Colgada; any surplus being sold for household purposes In course of thirty-four years more than two million *(Troy)* lbs. of silver were obtained in this department of the Chilian Republic. 69—153.

Copiapò. At *Quebrada Seca* foliated rocks of hornblende, quartz, calcareous-spar, and felspar, more or less mixed with several other minerals, are frequently interlaid, although they are sometimes also intersected, by bodies of quartzose, calcareous, and felspathic vein-stone unequally charged with earthy brown iron-ore, as well as with native copper and various varieties of copper-ore in smaller proportions. Trifling quantities of water, in the deepest works are rich in salts of soda. At *San Josè* rocks of much the same character as those of *Quebrada Seca* are traversed by two series of joints at the interferences of which masses of quartzose, felspathic, and hornblendic vein-stones are largely impregnated with earthy brown iron-ore and thinly sprinkled with various ores of copper. Nearly horizontal beds of recent sandstone—pierced at intervals by hornblendic crags — extend from the neighbourhood of Baranquilla to the valley of Copiapò. Great numbers of irregular joints traverse the rock in every part of its range; and on either side of these it rises slightly above the general level. At some three hundred feet above the sea, certain beds of this sandstone contain quantities of ill-preserved

and broken shells. At an elevation of, perhaps, one hundred and eighty feet, a railway-cutting near Caldera lays open successive layers consisting either of gravel, shingle, and fragments of rock bored by marine animals, or of shells of existing species in such abundance that they are exported for the sake of the lime contained in them. Notwithstanding the surface of *San Josè* is covered with sand impregnated with the salts of soda a shaft of five fathoms in depth affords copious streams of fresh water. At el Bramador near Copiapò loud noises are sometimes heard when large quantities of sand are drifting before heavy gales. During the writer's sojourn in Chili, more than three days seldom passed without an earthquake. 154—167.

BRAZIL.

Minas Geraës. The richest part of this productive Province,—situate between Congonhas do Campo on the south, *Candonga* on the north, tributaries of the River Doce on the east, and the Rio das Velhas on the west,—is about one hundred miles in length and from fifty to seventy in width. That portion of it which consists of undulating table-land and rounded hills, some two or three thousand feet above the sea, is covered with coarse grass *(Capim gordura)*; the rest, which rises into serrated ridges and isolated peaks five or six thousand feet high, is, in many places, still clothed with virgin forests. The auriferous series is made up of granite and gneiss, overlaid by micaceous and talcose slates, which are sometimes interlaid by quartz-rocks mixed with mica and talc. The micaceous and talcose slates are succeeded by clay-slate, which passes, at times, into chlorite slate, and often includes large masses of quartz. The clay-slate is followed, sometimes by an inconsiderable deposit of granular quartz and calcareous matter, but far more frequently by thin bands of specular and oxydulated iron, which commonly alternate with granular quartz *(Itabirite)*, and are, at intervals, mixed with the ores of manganese, as well as with talc and mica *(Jacotinga)*. In some cases, however, the clay-slate is not easily identified; and, at times, the *(Itabiritè* and *Jacotinga)* ferruginous, quartzose, and manganesic rocks are imbedded in the micaceo-talcose slates. Hornblendic rocks and siliceo-magnesian limestone occur amongst upper, schistose, parts of the system. The granite of *Candonga* contains gold alloyed with palladium; but that of the Caraça and of Caëthé

is barren. The quartzose talco-micaceous slate is often interlaid, —and occasionally intersected—by bodies of quartz; these—at *Santa Rita* (*a.*), *Rossa Grande* (*b.*), *Cstta Branca* (*c.*), *Paciencia* (*d.*), and *Coelho* (*e.*), are of widely different dimensions, and contain unequal proportions of gold, beside smaller quantities of iron-pyrites and the ores of antimony, bismuth, and tellurium, Quartz-rocks of granular structure are, at *Catta Preta* (*f*). traversed by vein-like masses of crystalline quartz, which mostly conform to two series of joints, but frequently ramify, and sometimes enclose (*horses*) bodies of granular quartz. The crystalline portions are traversed in all directions by short joints, which are often lined with earthy red iron-ore sprinkled with granules of gold. The clay-slate contains many auriferous beds; which—conforming to its cleavage— consist at *Tijuco* (*a.*) of spheroidal and angular bodies of brownish quartz, and at *Ouro Fino* (*c.*) of globular masses of iron-pyrites and of slate, enveloped in quartzose slate and colourless quartz. At *Gongo Soco* (*Camara*) short interlying beds of quartz and earthy brown iron-ore either dwindle and disappear in the rock, or terminate at its joints (*b.*). At *Morro Velho* (*d.*) the metalliferous deposit—coinciding sometimes with the cleavage, frequently with the joints of the rocks, but often oblique to both—assumes the character of a bed in some, but of a *lode* in other, places; both its course and its dimensions are therefore irregular; it consists in great measure of quartz, mixed, however, with great quantities of iron-pyrites, and with arsenical pyrites, yellow copper-ore, and other minerals in smaller proportions; these ingredients embed considerable quantities of slate, mostly microscopic, but occasionally in bodies of large size; their structure is generally, but not always, coincident with that of the neighbouring (*Country*) rock, which also they commonly resemble in composition; yet many of them are mixed and transfused with siliceous and pyritic matter; a thin, highly-inclined slice of slate (*tongue of killas*) separates the principal formation from the *North branch*; a somewhat similar one beneath it, in both the (*shoot*) endlong dip of the several ores coincide with flexures of the adjoining strata; between the slate (*Country*) and the vein-stone there is not uncommonly a gradual transition; but beds, and even laminæ of the former sometimes protrude from the sides (*walls*), and either partially, or entirely, sever the latter; all these vein-stones—as well as the

rocks which bound them—are more or less auriferous, but the pyritic portions are by far the richest ; even in them, however, an admixture of other minerals would seem necessary to their productiveness ; moreover, at various depths vein-stones of different hardness, afford gold, in unequal proportions and dissimilarly alloyed ; silver, however, is always the principal alloy. Lengthened experience dictated improved modes of treating the ores ; even from 1855 to 1861 the proportion of gold *extracted* increased from one-half to two-thirds of the *actual* (assayed) *contents*, and at the same time the cost of extraction was more than proportionally diminished. From 1834 to 1862 the produce of *Morro Velho* realized £2,229,487 and afforded a Net Profit of £661,737. At Ouro Preto *(Villa Rica)* particles of gold are thinly sprinkled through homogeneous, soft, blue, clay-slate. Quartzose micaceo-talcose slate, which affords mere traces of gold, succeeds the clay-slate at Ouro Preto and *Gongo Soco*. A thin bed of calcareo-siliceous matter, flecked with micaceous iron-ore and with talc, contains small quantities of gold at Cocaës (*p* 1.) and *Gongo Soco* (*r* 2.). The *Itabirite* (iron-mica slate) and *Jacotinga* conform to the micaceo-talcose slate which they overlie, and maintain —at the same time—a certain coincidence with the contour of the surface ; the selfsame beds, therefore, take different directions and dips in various parts of their range,—at *Antonio Pereira* (*a.*), *Santa Anna* and *Itabira* (*b*, *c*, *d*, *e.*), *Monlevade* (*f.*), *Boa Vista*, *Pitangui*, *Morro das Almas*, *Agoa Quente*, *Piracatú Pissaraõ*, *Fazendaõ*, *Duraõ*, and south of the Periçicaba (*g*, *h*, *i*, *j*, *k*, *l*, *m.*), the *Corrego de Saõ Miguel* (*o.*), *Cocäes*, the *Venda do Morro*, and *Gongo Soco* (*p*, *q*, *r.*). The *Itabirite* consists in great measure of granular quartz and sundry iron-ores ; these—with smaller quantities of other substances—frequently occur, either mixed or in alternate beds, but—especially in central parts of the formation —granular, scaly, or crystalline iron-glance prevails ; schistose structure is usually more pronounced amongst the alternations of iron-ore and quartz than where the ingredients are more exclusively ferruginous, but even in these it exercises a marked influence on the productive character of the neighbourhood. The *Jacotinga*—partaking the nature of the adjoining *(Itabirite)* rocks—consists in great measure of iron-glance, earthy black and brown iron-ore, manganese, and talc ; and—somewhat resembling them in structure—is slightly lamellar. The principal members

of the series, however, are certain conformable beds which open at intervals to width of some inches and for several feet, or even fathoms, in length and depth; of these enlargements the central portions contain rough *nuggets*, flakes, and granules, sometimes isolated, but often united by intertwining threads of gold; towards the edges and sides of the *bunches* grains and particles become more and more thinly sprinkled and the vein-stones at length merge in the ordinary *Jacotinga;* sometimes several such short, productive beds occur on identical parallels in the same formation; in all cases, however, the richest portions are the most highly inclined; the productive and the barren *(Shoots)* bodies of vein-stone coincide in position both with the—oppositely undulated or *rippled*—planes of cleavage in confronting portions of the *(hanging* and *foot walls)* upper and lower sides (*c, d, f, g, h, i, j, l, o, p, q.*), and with the several—*kindly* and uncongenial—strata where they interlie the joints *(h. r.)*, of the *(Country) Itabirite*, and at the same time, they all dip (endlong) from the nearest bodies of granite. At *Gongo Soco* a *(horse)* mass of *Itabirite* is both embedded in and penetrate by veins of auriferous *Jacotinga*. The gold of this formation is alloyed with silver at *Agoa Quente*, —with copper at *Duraõ*,—with palladium at *Santa Anna* and *Itabira;* all these substances, however, are alloyed with the gold of *Gongo Soco* which is associated with less silver, but with more palladium and copper, in deep than in shallow parts of the mine, and contains platina near the surface only. Short, thin *cross-veins* of quartz slightly displace some of the beds, but they soon merge in quartzose portions of the *Itabirite*. A broad band consisting of micaceous iron embedding crystals of oxydulated ore in some (*m.*), but of *(Carvoeira)* siliceous sand, earthy talc, manganese, and earthy brown iron-ore enclosing isolated masses of quartz in other (*n.*), parts of its range, has afforded gold at *Catta Preta*. The *Canga*—a breccia in certain, but a conglomerate in different, places, consists, in great measure, of various iron-ores, now and then including fragments of quartz and of slate (*d, l, p, r.*); at intervals it contains crystalline granules of gold (*d, l.*), and in one spot, at least, it yielded auriferous native copper (*l.*). Iron-ores from the *Itabirite* and *Jacotinga* are largely smelted in many parts of the district (*a, e, f, l, o, q, r.*). Joints in the *Itabirite* of *Gongo Soco* emitted a sufficiency of pure air for the ventilation of a long drift (*r*–3, 1.). The slaves of the Imperial

Brazilian Mining Association were well-treated, -clothed, and -fed; rewards were given for nicely-kept gardens, clean houses, and general good conduct, a savings-bank was established for them, and their children were taught to read and write. The duration and nature of their labour differed little from the periods and kinds common to young persons in the mines of Cornwall and Devon. The gold extracted by the Association at *Gongo Soco* realized £1,427,074, the working expenses amounted to £884,937, and the Government of Brazil exacted £333,180 as Provincial and Export Duty. The *Itabirite* is succeeded by talcose rocks, mostly of schistose structure, which enclose—bodies of siliceo-magnesian limestone,—short, thin, and generally-conformable, beds of—more or less granular—quartz largely charged with earthy brown iron-ore,—and broad bands of felspathic matter. The barren limestone of *Gongo Soco* (*a.*) is burnt for use, but at *Antonio Pereira* (*f.*) the rock is too siliceous for the lime-burner and too slightly auriferous for the miner. The beds of ferruginous quartz at *Descoberta* (*b.*), Cattas Altas (*c.*), *Fraga* (*d.*), *Thesoureiro* (*e.*), and *Antonio Pereira* (*f.*), are seldom or never quite destitute of gold, and portions of them all have been wrought to advantage; frequently also the surrounding rocks are productive for considerable distances. The gold of this series is usually of great purity; but at *Descoberta* it is alloyed with tellurium. Crystals of topaz occur,—now and then, in ferruginous talc-slate near Cattas Altas (*c.*); and—mixed on rare occasions with euclase—in unexampled abundance amongst the felspathic and talcose rocks of Capaõ and Boa Vista (*g.*). The

DETRITAL DEPOSITS of Minas Geraës are of different periods; and the gold contained in each of them may be traced to its parent formation. The older, coarser, and heavier *detritus (Cascalho)* —to the disruption and transport of which existing streams are inadequate—sometimes occurs above their present range. The greater amount of rain in wooded, than in unwooded, regions, and between streams and forests at their sources, were recognised in the earliest Mining Laws of Brazil. In spite of strict enactments, however, the auriferous districts of Minas Geraës are gradually denuded. Between Cattas Altas and Brumado, from Cäethé Cuiabá, and in many other places, now destitute alike of wood and water, the roots of *(Arvores de lei)* forest trees and the remains of *(Regos)* water-courses may yet be traced. In wet

seasons quantities of *debris* are still dislodged by streams insufficient to cover them after the rains have ceased. The sandy and earthy portions of such matter, together with the refuse from mining-works, continually find their way into the rivers; whence —for sake of the gold contained in them—they are gleaned and washed by *(Feiscadores)* poor freemen and slaves between seed-time and harvest. Many of these muddy streams, however, abound with fish of various species. Gold was obtained from Minas Geraës in 1599 ; but, until 1695, it had not been discovered *in situ.* As early as 1618, however, laws were promulgated which regulated the disposal of mineral lands, but reserved to the Crown a proportion of their produce. During several years this Royalty was nominally twenty per cent.; but at different times various stipulated weights of gold, and divers rates of capitation-tax on miners, were substituted. During a considerable period the impost on native-miners was at a much lower rate than on foreigners; but at length all Provincial Duties were abolished. For a great while the amount of Royalty paid by native miners exceeded (one hundred *arrobas)* 3,935 *(Troy)* lbs. a year; but before the abolition it had dwindled to (two *arrobas)* 78·7 lbs. only. The entire produce of the Province from 1700 to 1860 is estimated to have exceeded one million five hundred and seventy-five thousand *(Troy)* lbs. For a long time neither a goldsmith nor a stranger was allowed to remain there ; and, indeed the same prohibition extended even to native Portuguese—as well clergy as laity—unless they were appointed to office by the Crown. In order to ensure the payment of Royalty, it was declared illegal to remove gold which had not been converted into bars at the *(Casa de Fundicaõ)* mint; and even then the licence of a Government officer was necessary to protect it from forfeiture. This *(Guia)* certificate, that all legal imposts had been duly paid, was required until the ultimate abolition of Provincial Duties. 168–370.

NORTH AMERICA.

VIRGINIA. The metalliferous series wrought in Orange, Spotsylvania, and Buckingham comprehends talcose, micaceous, chloritic, and clay slate ; interlaid by quartzose beds, of variable, but at times of considerable, width ; which—bearing some 15°–45° E. of N.–W. of S., and dipping most frequently, though not invariably,

towards the N.W.,—conform to the planes of cleavage. Their siliceous and slaty ingredients—everywhere mixed with larger or smaller proportions of earthy brown iron-ore—are sprinkled with iron-pyrites and copper-pyrites at *Grasty* (*a.*) and *Booker* (*e.*), and with the same substances, as well as with copper-glance, earthy black copper-ore, galena, and the phosphate of lead at the *Buckingham* mines (*d.*). Many quartzose portions of all these beds are more or less impregnated with gold; which is alloyed with silver at *Grasty* (*a.*), with both silver and copper at the *Buckingham* mines (*d.*), and with tellurium at *Whitehall* (*c.*) and *Booker* (*e.*). The proportions of gold were larger in the shallower and wider, than in the deeper and broader, parts of the formation, at *Booker* (*e.*). Considerable quantities of finely-granulated detrital gold have been obtained in the neighbourhood. In 1852 most of the labour was performed by slaves; who earned (for their masters) higher wages, but were fed less liberally, than slaves in Brazil. 371—384.

Michigan. The metalliferous series of Lake Superior rests on granite, gneiss, and hornblendic rocks in some, but on quartzose, talcose, micaceous, and chloritic slates in other, places. Dykes and beds of hornblendic and felspathic rocks are numerous; and, in their neighbourhood, the ores of iron have been largely wrought. Veins of granite penetrate the lower hornblendic rocks. Sandstones, interlaid by trap-rocks and conglomerates, rest unconformably on the slates, and sometimes touch the granite. The central range of greenstone, which traverses Keweenaw Point, is, on both sides, overlaid by crystalline trap-rocks,—consisting, in great measure, of labradorite, hornblende, chlorite, and epidote; and these are interlaid by beds, of amygdaloid and of conglomerate. Peculiarities of composition or of structure, however, characterize most of the different beds. No corresponding axis of greenstone intersects the district of Ontonagon, in which bands of amygdaloid and of conglomerate—although thinner—are more numerous, and epidote occurs more frequently, than at Keweenaw. The rocks of Keweenaw bear N.E.–S.W; those of Ontonagon some 30° N. of E.–S. of W.; the *lodes* in the former range 29° W. of N.–E. of S.; of the latter 37° N. of E.–S. of W.; the one series dips 77°, the other 55°; such as approach a meridional direction, and are highly inclined, are narrower than

those transverse to the meridion and inclined at lower angles. The vein-stones in both districts have a general resemblance; prehnite, however, is rather more plentiful in Keweenaw than in Ontonagon, and epidote at Ontonagon than at Keweenaw. In both, also *(horses)* masses of the immediately adjoining rocks are imbedded in the *lodes* and impregnated and veined with their characteristic minerals. Of three series of joints which traverse the *lodes*, two are common to them and to the neighbouring *(Country)* strata. The vein-stones, especially where they are bounded by beds of amygdaloidal trap and of conglomerate, contain native copper in grains, threads, and irregular *(nuggets)* masses, which at the *Cliff* mine (*c.*) are often determined to faces of crystallization, or—as at *Douglass Houghton (Henwood)*—to the joints (*i.*); sometimes, however, parallel sheets of metal interlie an earthy matrix, as they do in the *Cliff* and *Rockland* (*c*, *k.*) mines, and at intervals slabs of copper occupy the entire width of the *lodes*. The largest masses are cut into pieces, adapted to the dimensions of the *levels*, and dislodged by aid of machinery (*c*, *d*, *k.*). At the *North American* (*b.*), *Cliff* (*c.*), *Fire Steel* (*f.*), and *Douglass Houghton* (*i.*) mines cavities in the amygdaloidal, and, at the *Douglass Houghton* and *Minesota* (*i.*) mines crevices in the conglomerate, are occasionally filled with metal, which—except that it now and then includes masses of either rock—entirely replaces the earthy ingredients. Native copper from the *Cliff* mine (*c.*) is of higher specific gravity than smelted metal. In the *Cliff*, *South Cliff*, and *Douglas Houghton lodes* (*c*, *d*, *i.*) both the barren and the productive bodies *(shoots)* of vein-stone have the same endlong dip as the beds of rock which adjoin them. Where the *Cliff lode* (*c.*) traverses certain well-recognized portions of the strata, small incrustations of virgin silver adhere to —but are not alloyed with—the native copper it contains. It appears that at *Douglass Houghton* (*i.*) the smallest proportions of metal occur in the softest parts of the *lode*, but that in their vicinity the rocks are unusually hard. A bed of chloritic conglomerate interlying other strata, displaces *(heaves)* the *Cliff lode* (*c.*) towards the *left-hand*, and to the side of the smaller angle (L. —S. A.); and similar dislocations occur at Ontonagon (*i.*). The *Douglass Houghton lode* (*i.*) is represented merely by a few unconnected masses of vein-stone on one side of a *cross-vein* which intersects it; and, in another part of its range, it is displaced,

towards the *left-hand*, by a joint which crosses it about right-angles (L.—R.A.). Masses of native copper are imbedded in the *drift*, which covers great part of the country. A *Man-engine* has been already set up at the *Cliff* mine (*i.*). The ice which accumulates, in some of the works, during winter, frequently remains unthawed until the following autumn (*e, i.*); in order to avoid interruption in the shafts, and to preserve the water in the pumps from freezing, air—artificially heated—is sometimes conducted downward from the surface (*i.*). The engines, however, are more cheaply worked by coal brought a distance of seven hundred miles, than by wood grown on the spot (*i.*). Very large profits have been realized in the *Cliff*, the *Minesota*, and several other mines; but, on the whole the produce of this region has not yet repaid the enormous capital expended in it (*c.*). In both Keweenaw (*a.*) and Ontonagon (*i.*) extensive ranges of prehistoric copper-mines have been discovered; and many implements, some weapons, and several ornaments have, from time to time, been found (*a.*). 385—489.

New Brunswick. The granite which, for some distance, forms both banks of the Big, Middle, and Little (Nepisiguit) rivers in the county of Gloucester (I.), is intersected by a dyke of felspathic porphyry at Glendinning's island, and by veins of quartzose granite near the falls of the Pabineau and at the Middle river. The slate series (II.) comprehends many beds of felspathic and hornblendic rocks, both of compact and of schistose structure; it consists, however, to a much greater extent of clay, and of chloritic, slates; In different parts of the Middle river, also, felspathic and hornblendic slates overlie, alternate with, or are penetrated by veins of, granite (*a.*). From some distance below the falls of the Tattagouche (*d.*) to Daly's eastward (*c.*) on the same river, homogeneous clay-slate prevails. At the Long meadow, and from the Middle landing to the Red brook (*b.*) on the Big river, and at the fall of the Tattagouche (*d.*) chlorite abounds. Near the Narrows (*i.*) from the Middle landing to the Portage brook (*j, k.*), and at the Grand fall (*m, n.*) of the Big river, and from ten to twelve miles up the Middle river (*h*), the slates are more or less quartzose. Near the Chain of rocks (*l.*), and on the edge of the Grand fall of the Big river (*m, n.*), at the falls of the Little river (*g.*), at the fall of the *Tattagouche* (*d.*), at Armstrong's brook

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and Clarke's camp (*f.*), felspathic and hornblendic rocks interlie the slates. Earthy brown iron-ore occurs at the Red brook (*b.*), the Narrows (*i.*), and at the Middle landing (*j.*), on the Big river. Iron-pyrites is obtained below the fall (*e.*), and at Daly's (*c.*) on the Tattagouche, at Clarke's camp and at Armstrong's brook (*f.*), near the falls of the Little river (*g.*), and at the Narrows (*i.*), between the Middle landing and Portage brook (*k.*) on the Big river. Copper-pyrites has been observed at (*d.*) and below (*e.*) the falls of the Tattagouche as well as at Daly's (*c.*) towards the east, near Clarke's camp and at Armstrong's brook (*f.*), and at the Grand fall of the Big river (*n.*). Crystals of copper-glance are thinly sprinkled at the fall of the Tattagouche (*d.*). Galena accompanies calcareous-spar at Armstrong's brook (*f.*). The oxide of manganese is scattered through masses and veins of quartz at the Tattagouche fall (*d.*). *Crinoidea* have been discovered in the same locality (*d.*). A conglomerate (III.) of quartzose and slaty pebbles rests, in nearly horizontal beds, on the granite from the Red brook up the Big river (*c.*), and a similar rock which overlies the slate at the Long meadow (II. *b.*) is succeeded by siliceous sandstone (*b.*). At Blackstock's mill on the Tattagouche a conglomerate of slate and quartz rests unconformably on schistose rocks (*a.*). Near the road from Bathurst to Miramichi the left bank of the Big river consists of siliceo-micaceous sandstone, quartzose conglomerate, and argillaceous shale (*d*, *e*, *f.*) ; but on opposite sides of a joint, in one locality, the strata are differently disposed. The remains of plants, and lignite interlaid and veined with vitreous copper, abound in the shale; which contains also nodules of copper-pyrites and of vitreous copper, sometimes separately aggregated, but more frequently an envelope of one ore surrounds a kernel of the other. Both the lignite and the masses of ore are encrusted with the carbonates of copper. At Parrot's brook, east of Bathurst, an erect fossil trunk rooted in shale is encompassed with ferruginous sandstone alternating with carbonaceous shales rich in vegetable remains (*f.*). 490—510.

JAMAICA.

In a low hill of hornblendic granite on the eastern confines of Saint Thomas in the Vale, a portion of the rock, which in direction coincides with the joints of one series, and preserves a

general width of four or five fathoms, is unequally sprinkled with small rough spheroids and other shapeless masses of copper-pyrites, earthy black copper-ore, specular iron, and earthy brown iron-ore, frequently invested with malachite; for the most part they are isolated, but in some cases microscopic threads of copper-pyrites unite them (*a.*). A similar (? the same) body of hornblendic granite, charged in like manner with ore of copper and iron, is traced for some distance in the adjoining greenstone (*b.*). 511—512.

SPAIN.

At Huidobro in Old Castile concretions of the blue carbonate of copper occur at irregular distances in a stratum of buff-coloured siliceous sandstone (*a.*); which is separated by a barren bed of tenaceous clay (*b.*) from a great thickness of quartzose sandstone (*c*). Of this body the productive part may average twenty-five, but it seldom exceeds forty, feet in thickness. Earthy brown iron-ore is sometimes abundant, crystals of the sulphate of barytes are grouped in some of the beds, and lignite abounds in some of the lower layers; isolated bodies of iron-pyrites, copper-pyrites, earthy black copper-ore, and vitreous copper are not uncommon, whilst the blue carbonate of copper is a frequent constituent and malachite is yet more plentiful. Near several horizontal joints the sandstone, is both more ferruginous and more richly charged with copper-ore than elsewhere. Some of the mines have afforded notable quantities of petroleum (*e.*) In great part of the neighbouring district greyish-white limestones overlie the sandstone (*d.*).

At Eardiston in Shropshire the New Red Sandstones consist in great measure of granular quartz, mixed, at intervals, with ferruginous clay. A portion of the mass, which varies from a few inches to several feet in width,—and is sometimes bounded by (smooth walls) joints, but occasionally shades into the adjoining (*Country*) rock,—contains much earthy brown iron-ore in some, and is, more or less, charged with the green carbonate of copper in other, parts of its range; grains of grey copper now and then present themselves, and thin incrustations of malachite line many of the (*vughs*) cavities. The cupriferous deposit is intersected, but without displacement, by a *cross-vein* of clay. 513—516.

FRANCE.

The ancient mine of *Chalanches*, near Bourg d'Oisans, is wrought in granitic gneiss, on several widely divergent *lodes*, of compara-

tively low inclination; their ingredients resemble, in some measure, although they are not identical with, those of the adjoining rocks, and are mixed with many metallic minerals; amongst which native silver, and the ores of silver, of cobalt, of nickel, of copper, and of iron occur most frequently. A *cross-vein* which differs from the *lodes* less than some differ from others of them in direction, but is of higher inclination than theirs—intersects and *(heaves)* displaces one of the *lodes*. The works were carried on at elevations so great that, during great part of the winter, people lodged at the mine were debarred all intercourse with their nearest neighbours. 517—529.

THE CHANNEL ISLANDS.

SARK. The metalliferous rocks of Sark consist in great measure of felspar and hornblende; mixed, however, with smaller quantities of several other substances. Several *lodes* have been laid open, but one of them only (*b.* 1—4 A.)—at *Sark's Hope* mine, in Little Sark, the south-western part of the island,—has proved productive. From this considerable quantities of several silver-ores were obtained; sometimes separately aggregated; but, perhaps, more frequently associated with various compounds both of lead and of copper. From the surface to sea-level the ores were principally the salts of these metals, but at greater depths their sulphurets prevailed. The masses *(shoots)* of ore—conforming in some degree to the structure of the adjoining rocks—dip endlong towards the south-south-west; and in that direction they have been pursued for some distance beneath the sea. 530—539.

IRELAND.

WICKLOW. The homogeneous dark-blue and variegated clay-slates which prevail in the south-west, but graduate into massive siliceo-felspathic rocks in the north-east, of the district of Ovoca, are interlaid by (the *Sulphur-course)* a metalliferous band which from *Connorree* in one, to *Ballymurtagh* in the opposite, direction, has been wrought for a width of from six to more than seventy feet. Throughout its entire range the shallower parts consist chiefly of earthy brown iron-ore, sprinkled with iron-pyrites, various ores of copper, and of several other metals. At greater depths iron-pyrites becomes the principal ingredient; but, at

intervals, it includes bodies of yellow copper-ore; quartz, although less abundant than in most other metalliferous deposits, is often a large constituent; and slate—from mere microscopic specks to *(horses)* masses of several fathoms in length and depth,—abounds in almost every part. Auriferous silver has been found imbedded in earthy brown iron-ore at *Cronebane*, and thinly scattered, in a state of extreme subdivision, amongst the *sulphur-ore* of *Connorree*. Gold occurs in both the earthy brown iron-ore and the pyrites of *Ballymurtagh*, but in proportions far too minute to repay the cost of extraction. A striking peculiarity of the formation is that the iron-pyrites, the copper-pyrites, and the slices of slate which interlie them, all display,—as well in direction and dip as in degree—the selfsame schistose structure as the adjoining *(Country)* slate; differences between the *(Country)* rocks and the vein-stones, however, are more distinctly marked where they are bounded by (joints and planes of cleavage) lines of structure than elsewhere. North-west of the principal metalliferous bed, but west of the Ovoca, a second, similar, broad band of ore has been largely wrought at *Ballymurtagh*. On either side, yet within short distances, of the *Great Sulphur-course*, parallel beds of similar character, but of smaller dimensions, appear and vanish at intervals; some of these—as well as of numerous small veins which accompany cross-joints in the rock—contain, especially towards the south, however, larger proportions of copper-ore than most other parts of the formation. One of these (the *South-branch* in *Connorree*), although of much the same composition as the rest, maintains—like the *Main lode* at *Bearhaven*—a lower inclination than they or than the cleavage-planes of the contiguous slates. Of three *cross-veins*, which intersect the *Great Sulphur-course* in *Cronebane* and *Tigrony*, two *(heave)* displace it in opposite directions, but the effect of the third is yet unknown. Three *cross-joints* traverse it at *Ballygahan*, and all *heave* it the same way, but to unequal distances at different depths; at *Connorree*, however, similar joints occasion no displacement. From 1840 to 1866 the exports from this district amounted to 105,432 tons of copper-ore, and 1,960,119 tons of *(sulphur-ore)* iron-pyrites, besides large quantities of hematite and earthy brown iron-ore.

The mine-water is everywhere more or less impregnated with metallic salts; in one mine, indeed, to such an extent that the pumps were protected from it by wooden linings, and the *(plungers)*

forcers were also of wood. The precipitation of copper from such water, by the immersion of iron, was introduced at *Cronebane*, about one hundred and fifty years ago, by a Cornishman, who had become acquainted with the process in his native county; and from that time to the present it has been carried on, in various parts of the neighbourhood. The precipitate is greatest in autumn and early winter; but it is deposited more rapidly in warm than in cold weather, and from running than from still water.

The *Parys* and *Mona* mines have been uninterruptedly wrought, in the clay-slate of Anglesea, on masses, beds, and *strings* of quartz, quartzose-slate, iron-pyrites, and yellow copper-ore, from the discovery of *copper-turf* at the surface in 1768, until now. The principal works—which are open to the day—comprehend an area exceeding seventeen acres and a half, and extend from eighteen to twenty-three fathoms below the surface; whilst separate metalliferous beds in the immediate vicinity are wrought to much greater depths. The richer ore was prepared in the usual manner; but the poorer was burnt, as at Agordo. By burning, most of the ore in each lump was determined towards the centre, although some yet remained in the outer part. Water from the mine—already rich in the salts of copper was pumped on this refuse burnt ore; and, having percolated through it, was conducted into shallow reservoirs thickly spread with scraps of iron. Of late years, however, the burning has been discontinued and the water passes directly from the mine to the *precipitation-pits*. From 1862 to 1866, there were consumed at the *Parys* mine 2,746 tons of iron, and the 1,546 tons of precipitate obtained contained about 108 tons of fine copper. From 1832 to 1866 the consumption of iron at the *Mona* mine amounted to 30,386 tons, the precipitate weighed 30,735, and the fine copper 2,977 tons.

The results obtained at *Chacewater* suggested the operations which have since been conducted in other parts of Cornwall, in Ireland, on the Continent, and in the West Indies; but it was not until 1854 that the mineral contents of the enormous stream of mine-water which, for more than a century, had issued from the *Great Gwennap Adit* was submitted to experiment; subsequently, however, precipitation-works have been established from the point of its exit to the sea. 540—592.

WATERFORD. The mine of *Knockmahon* is, for the most part, wrought in variously-coloured, yet generally homogeneous, slates; but, in some of the works, massive rocks have been observed. The *lodes* bear 30°–45° W. of N.—E. of S., and consist, in great measure, of quartz, quartzose slate, slate, slaty and felspathic clay, chlorite, and calcareous matter; near the surface they contain also small quantities of earthy brown iron-ore, at greater depths iron-pyrites and several varieties of copper-ore obtain, and the

deepest works have been rich in copper-pyrites; differences of composition, however, often characterize subordinate veins, into which the *lodes* are sometimes divided by longitudinal joints. The *lodes* bear obliquely to the trend of the cliff, and incline unconformably to the cleavage of the slate; but the *(Shoots)* bodies of ore and of vein-stone they contain—adapting themselves to the several beds which adjoin them—pass endlong, beneath the sea, and have been largely worked there. Some of the workmen have pursued their shallower works so incautiously, that the sea has, more than once, found its way into the mine. *Cross (flucan) -veins*—which course 20°—45° E. of N.—W. of S., but have opposite dips—intersect and—save in one instance—displace *(heave)* the *lodes;* always, however, towards the *right-hand* and to the side of the *greater-angle* (R.—G. A.). In the single exceptional case one *branch* of a *cross-vein* simply intersects, whilst other *branches* of the same vein displace, the *lode.* From 1825 to 1865 the produce of the mine realized £1,399,232, and the Shareholders received a net profit of £489,153. 593—601.

Cork. At the *Bearhaven,* or *Allihies, Mountain-mine* the rocks consist mostly of siliceous and chloritic or talcose matter, unequally sprinkled with the carbonate of lime, and minutely veined with quartz; adjoining, and within short distances of, the *lodes* they assume pale-buff, or lilac hues, and a thick-lamellar structure prevails; elsewhere they are blue and fissile. Three series of joints are common alike to the rocks and *lodes.* The *Main lode* and the planes of cleavage in the adjoining slates have much the same strike; but—exhibiting almost a solitary exception—its dip is at a lower angle than theirs. The *Mountain lode* is—as well in direction as in underlie—oblique to both. From the surface to one hundred and forty fathoms deep the *Mountain lode* comports itself as a *branch* from one side of the *Main lode;* but at greater depths the north (side) *wall* of the latter preserves its continuity and severs the former; the identical body of rock intersected by the *lode* in one spot, thus intersecting the selfsame *lode* in another. The *lodes* are seldom equally productive at the same depths; yet in both the most highly inclined parts are usually the richest. Their principal ingredient is hard, massive, quartz, tinged with the salts of copper in some, but with earthy brown iron-ore in other, places; chloritic or talcose matter is not uncommon, and isolated

masses of calcareous-spar and of the carbonate of iron present themselves here and there; numberless angular bodies *(horses)* of slate—varying in size from a fraction of an inch to some fathoms in length, depth, and thickness, resembling the adjacent rocks in composition and generally coinciding with them in cleavage—are enveloped in the other vein-stones. Iron-pyrites, vitreous copper, and some other metallic substances occur at intervals, but yellow copper-ore prevails. A *cross-vein* intersects, but does not *(heave)* displace the main *lode.* Notwithstanding the works have been opened to considerable depths, in schistose rocks, at less than a mile from the sea, the streams which enter them merely suffice for use at the surface. During thirty years past all ore and rubbish have been drawn out of the mine on a railway worked by a small high-pressure steam-engine placed at the *adit.* Forges for the repair of tools have long been established at various depths, and of late a *Man-engine* has been set up. 602—610.

KERRY. The mine of *Ardtully* was worked on a metalliferous deposit which—for great part of its course—is bounded by (? Carboniferous) slate on one side and by thin-bedded Carboniferous limestone on the other; in one part of its range, however, slate occurs on both sides. But whether traversing the slate, or contained within it in one and limestone in the opposite *wall*, the earthy ingredients of the *lode* partake, to some extent, the nature of the adjoining rocks; whilst the ores of copper scattered through the vein-stones are, at the same time, characteristically different. A nearly parallel metalliferous repository (the *Forge lode)*—wholly contained in the limestone — consists chiefly of greyish limestone and calcareous-spar, but sometimes one, sometimes the other, prevails. To a depth of twelve fathoms purple copper-ore abounded; and vitreous copper, copper-pyrites, and earthy black copper-ore occurred in notable quantities; thence, downward, however, the ores rapidly declined, and at length they appeared only in granules and thin strings sparingly distributed through the vein-stones. A second coincident band of calcareous matter, on the same meridian, afforded lead-ore only; but whether this is, or is not, the equivalent of the formation wrought at *Shanagarry*, towards the west, has not been ascertained. A *cross-vein* intersects both the slate and the limestone, as well as the *Ardtully lode* where it interlies them, but it occasions no *(heave)* displacement of either. 611—622.

MEATH. At *Brownstown* beds of crystalline, blackish-blue Carboniferous limestone alternate with thin layers of calcareo-siliceous shale; the former at intervals, the latter everywhere, charged with organic remains. The limestone contains two bands which —partaking the nature of the adjoining rock *(Country)*—consist in great measure of calcareous-spar, mixed and frequently veined, however, with granular, massive, and crystalline quartz. Angular bodies of limestone are imbedded indifferently in the siliceous and the calcareous ingredients, and sometimes partly in either. Near the surface earthy brown iron-ore is scattered through friable portions of both the calcareous-spar and the quartz; and these are often interspersed with malachite and earthy black copper-ore. At greater depths the matrix is, at intervals, sprinkled and striped with copper-pyrites, which is frequently invested, and the crevices and joints are often faced, with earthy black copper-ore; but in such places malachite is seldom found. In all parts of both repositories the ores of copper prefer the siliceous, to the calcareous, vein-stones. At seventeen fathoms from the surface two joints of a large *Encrinite* were discovered in a quartzose *gangue*, and somewhat deeper a specimen of another organism (? *Turbinolia)* was found imbedded in a subordinate vein of massive copper-pyrites. 623—626.

THE DETRITAL GOLD OF WICKLOW. The beds of several small streams, which rise on the north-eastern slope of Croghan Kinshela, and both east and west of Croghan Moira, consist of gravel, shingle, boulders, and angular blocks of divers slates, frequently mixed with pebbles of granite, and of other earthy substances, as well as with masses of several ferruginous minerals, a trifling amount of tinstone, fragments of other ores, and minute proportions of gold; all imbedded in, sand and clay, the *débris* of neighbouring rocks and veins. It appears that gold was discovered at Ballinvalley in 1796; and that the rush of people to the spot, shortly attracted the attention of Government. Commissioners were immediately appointed to direct systematic operations; and up to 1798—when they were interrupted by popular commotion —their works had been remunerative. In 1801 proceedings were resumed, and openings were also made at Ballycreen and Ballynacapogue; but—proving less successful than before—they were shortly abandoned. In 1842, and again in 1857, trials were

carried on by private Companies, but, on both occasions, they were soon relinquished. During intervals between the operations of Government and of the two Mining Associations, the refuse from their works, and the beds of the streams, were continually gleaned by the peasantry. The *detritus* is, in general, shallow enough to be conveniently wrought by *open-cutting;* but, in one instance, at least, it was worked by means of shafts sunk to the *(shelf)* unbroken rock, and by *(levels)* drifts along its surface. The quantities of gold respecting which accounts have been obtained amount to more than one hundred and fifty *(Troy)* lbs.; and it is believed that much beside was, from time to time, collected and carried off by the people. Some of the *nuggets* found at first weighed many ounces a piece; but, even then, most of the gold consisted, and now the whole consists, of scales and granules of very small sizes. Whether the masses are large or small, most of them seem to have suffered great attrition; yet amongst them—as amongst the detrital gold of most—if not of all, other countries—small well-preserved crystals have been sometimes obtained. Its quality, like that of stream-gold generally—is very good. Attempts were made, both by the Government and by the Carysfort Mining Company, to discover the parent formation, but without success; for—until recently amongst the ores of *Ballymurtagh*—no part of the district had afforded gold *in situ.* 627—634.

GREAT BRITAIN.

MERIONETHSHIRE. At *Clogau* the *Saint David lode* is bounded on the south or lower *(foot-wall)* side by rocks of felspar and chlorite, thinly sprinkled with quartz and calcareous spar; but on the north or upper *(hanging-wall)* side by homogeneous slates, either enclosing masses, or alternating with beds, of felspathic, chloritic, siliceous, and sparry matter. All these are cleaved at high angles, and divided by two series of persistent joints, as well as by others taking different directions and of shorter range. The auriferous repository varies very greatly in width, maintains nearly the same direction as the joints of one series, and—although sometimes inclining towards the north—is, on the whole, nearly perpendicular. Its principal constituents are quartz, calcareous-spar, and—as the adjoining *(Country)* rock is of one kind or other—either felspathic and chloritic

matter, or homogeneous slate; these several ingredients are often separately aggregated, but, possibly, as frequently, mixed. Smaller quantities of pearl-spar, the sulphate of barytes, and other earthy minerals occur at intervals. Near the surface earthy black iron-ore abounds; somewhat deeper, yet in comparative shallow portions of the *lode*, iron-pyrites and copper-pyrites are common; but—although peculiar to neither of the vein-stones—they are most plentiful in a quartzose matrix. Granules of blende and galena, and crystalline scales of tetradymite are not unfrequent. Both the quartz and the calcareous-spar are sprinkled with particles and grains of gold; and intertwined with golden threads which unite in small *nuggets* at their reticulations. The gold may, perhaps, be less plentiful, but it is of coarser grain, in quartzose than in sparry, parts of the deposit. From June 1860 to December 1867 the mine afforded 1,008 *(Troy)* lbs. of gold, which averaged twenty-two carats fine. 635—642.

Perthshire. At *Corri Charmaig* the quartzose mica-slate which prevails, near the head of Loch Tay, is associated with felspathic and hornblendic rocks, of schistose structure, comprehending a broad metalliferous band, which in different parts of its range contains vein-stones of separately-crystallized felspar and hornblende, variously-coloured serpentine veined with diallage, steatite, asbestus, and talc—passing into chlorite—thickly sprinkled with garnets. The chromate of iron—as well in crystals and narrow reticulated veins, as in angular and rude spheroidal masses,—occurs in several parts of the repository; but mostly invested with talcose matter, and always in a vein-stone of serpentine. The formation is intersected by two series of veins; but numberless others, of short range, are peculiar to the serpentine; and it may be noteworthy that the *(bunches)* masses of ore are seldom alike in quality, and frequently their forms are dissimilar, on opposite sides of the joints. From 1855 to 1860 some seventy tons of ore were quarried; of this some realized five Pounds and two shillings (£5 : 2 : 0) per ton, the rest remained unsold.

Towards the middle of the last century the neighbouring lead-mine of *Tyndrum* was wrought to advantage under the superintendence of Mr. Rudolph Erich Raspe, who—when the German system, of *levels*, *winzes*, and *back-stopes*, was substituted for the *bottom-stopes* which until then prevailed in Cornwall—had been already employed at *Dolcoath;* where, according to local tradition, he composed a well-known work of fiction. 643—649.

At *Tomnadashan*, south of Loch Tay, the prevailing mica-slate is traversed by a broad band, composed mostly of felspar, hornblende, chlorite, and quartz, which present felspar porphyries in some, but greenstones in other, parts; the former—often containing isolated crystals of felspar—are usually determined to the middle, the latter towards the sides, of the formation; bodies of either rock, however, enclose masses, and are penetrated by veins, of the other. Two *lodes*, bearing respectively S.E.—N.W., and 25°—30° S. of E.—N.W., traverse both the greenstone and the porphyry; their principal vein-stones, whilst in the former, are felspar and hornblende, but in the latter they consist, in great measure, of felspar and quartz. Near the surface earthy brown iron-ore, small *bunches* of copper-pyrites, and nests of earthy black copper-ore sprinkled with malachite are of common occurrence; but downward the earthy ore is replaced by pyrites, yellow copper-ore is more plentiful, and granules of fahlerz and of galena are thinly sprinkled through the matrix. As the *lodes* converge, the rock between them is intersected by numberless intertwining veins of felspathic, hornblendic, quartzose, and chloritic matter, which give the entire mass a brecciated character. The sulphuret of molybdenum has seldom been noticed *in* the *lodes;* but—accommodating itself to the striæ, which score both the vein-stones and the rocks at their contact, it,—not uncommonly, shows itself as a slickenside. On the margin of the lake, however, it appears in small crystals scattered through the porphyry and facing its joints. 650—654.

CORNWALL. THE CARADON DISTRICT comprehends—the south-eastern portion of the Bodmin-moor granite,—the slates which skirt it,—the hornblendic rocks associated with the slates,—and the *elvans* which—although imbedded in granite at intervals,—usually traverse both granite and slate. But beside the vast sheet of slate which extends, towards the east and north-east, from the granite of this region to the confines of Cornwall, a tract of slate scarcely a mile in length or half-a-mile in width, is bounded on one side by the granitic slope of the Cheesewring and on the other by a body of granite which reaches most of, if not all, the way from *Caradon* to *Knowl.* Within this patch of schistose rock, however, the S., upper side *(hanging-wall)* of the *Phœnix lode* to about thirty-five fathoms from the surface consists of slate;

whilst the confronting portion of the N., lower *(foot-wall)* side, and both sides *(walls)* at all greater depths, are composed wholly of granite. The shallower parts of other *lodes* in the immediate vicinity seem likewise bounded by slate on their (S.) upper, but by granite on their (N.) lower, sides; but whether these bands of granite may, or may not, traverse the entire width of slate, has never yet been ascertained. At *Marke Valley*—on the junction of the great slate-formation with the granite—the *lode*, which dips towards the north, is accompanied on its N. or upper *(hanging-wall)* side, to a depth of thirty-six fathoms, by slate; but in the opposite parts of its S. or lower *(foot-wall)* side, and at greater depths on both sides, by granite. Generally speaking, the granite is composed of felspar, quartz, and mica; the joints by which it is traversed, as well as the *bedding* which conforms in some measure to the contour of the surface, are conspicuous at the Cheesewring, where the rock is largely quarried for exportation. On the confines of the formation schorl is frequently a constituent; in the vicinity of the *lodes* chlorite is not uncommon; and in more than one part of the district tin-ore is a large ingredient. The slates consist—as the granite in contact with them also consists—chiefly of felspar and quartz; mixed with either mica or chlorite; and, at some distance from the granite, they are occasionally interlaid by hornblendic rocks. Several *elvan*-courses—bearing 15°—30° N. of E.—S. of W.—intersect, indifferently the granite and slate; and—apparently unconnected—masses of *elvan* are, here and there, imbedded in the granite. In the different *(Countries)* rocks their components are, perhaps, scarcely identical; usually, however, they contain crystals of quartz and of felspar isolated in a basis of quartz and felspar, now and then, sprinkled with mica and schorl. The *lodes*—comprehending the several minerals of the adjoining rocks—consist, in great measure of quartz, chlorite, and felspar, associated, at intervals, with schorl and mica; sometimes separately aggregated, but more frequently intimately mixed. The joints of one series—well marked in the rocks—take much the same direction as many of the *lodes;* and — traversing them longitudinally — thus develope subordinate *slices*, *veins*, or *combs*, which, not uncommonly, display characteristic differences of composition and structure. Both N. and S. of the Caradon range the shallower parts of the *lodes* often contain earthy brown iron-ore; but it and the minerals associated with it

are not exactly alike on opposite sides of the granite. In the N. portion of the granite, and in the contiguous slate, dark-brown and blackish iron-ores are scattered through hard, massive, cavernous quartz, and—downward especially—mixed with chlorite; in this congenial matrix tin-ore is sometimes abundant. Softer, and lighter-coloured, iron-ores and granular quartz are—in the same neighbourhood—impregnated with several ores of copper. On the S., however, the outcrops of the *lodes* consist of soft, yellowish and reddish-brown iron-ore, granular and friable quartz, chlorite, and fluor, and in these copper and many of its ores often abound. Thus the *lodes* on one side of the granite afford tin-ore and copper-ore, but no fluor; whilst those on the other yield fluor and various ores of copper but are destitute of tin-ore; which, nevertheless, is an ingredient of the neighbouring rock. The direction of the *lodes*—ranging between 5° S. of E.—N. of W. and 35° N. of E. —S. of W.—is, on an average, some 18° N. of E.—S. of W. The *bedding* of the granite at the Cheesewring and the cleavage-planes of the slate throughout the district decline *from* the central body of the granitic formation; the *lodes*, on the contrary, dip generally *towards* it. The *lodes* peculiar to the granite measure about 2·, but those which, wholly or in part, traverse the slate average 6·8, the general mean being about 3·2, feet in width. The *cross-courses*—partaking in some measure the nature of the rocks they intersect—contain granitic matter when in granite, and *elvan* when in *elvan*; but—differing in this respect from the *lodes*, which contain larger proportions of quartz—they are usually more felspathic than the *(Country)* rocks; moreover, there seems an occasional approach to uniformity in the positions of the crystals of felspar they include. Their directions—differing little from those of one well-pronounced series of joints—range from 6° E. of N.—W. of S. to 24° W. of N.—E. of S. and average 13° W. of N.—E. of S.;—more highly inclined than the *lodes*—they dip just 80° from the horizon, and—in this respect resembling the *lodes* on both sides—incline towards the great body of granite. In this district—as throughout Cornwall generally—the *cross-courses* are rather broader than the *lodes*; they vary from 0·6 foot to 24 feet, and average 4·6 feet, in width. Of the *lodes* intersected by *cross-courses*, some are *(heaved)* displaced towards the *right-*, others towards the *left-hand*, and in a few instances the intersections are unaccompanied by displacement.

The mean amount of displacement is greater near the surface than at considerable depths; and by wide than by narrow *cross-courses*. One of the principal *cross-courses*, however, is intersected by a *(course)* vein of quartz. Copper is precipitated from the drainage of an abandoned mine; and from water used for household purposes in the neighbourhood. Notwithstanding the extent of early tin-mining in the vicinity, and that copper-mines had been long, largely, and profitably wrought, as well on both sides of the Tamar, as in many parts of Western Cornwall, it was not until 1835—1840 that they were opened with success on the slopes of Caradon; yet Railway-waggons were adapted to at least one inclined shaft in this region before they were generally used in other parts of the County. In 1851, 5 water-wheels and 13 steam-engines worked the pumping and *stamping* machinery, and more than 1,200 people were employed, in the district. In 1868 *East Caradon* and the *Phœnix* mines had already yielded large profits; and at *Marke Valley* £50,000,—at *West Caradon* about £110,000,—and at *South Caradon* £315,605 had been divided amongst the shareholders. 655—698.

The Lead-mines of Menheniot, Lanreath, and Saint Pinnock are opened in schistose rocks of greenish, brown, drab, or dun-colour near the surface, but of dark-blue or blackish hue at greater depths. Nests of pulverulent ferruginous matter (? of organic origin) occur here and there in a shallow quarry between *Wheal Trelawny* and *Wheal Mary Ann*, and similar bodies, as well as *Crinoideal* remains, are obtained on the way-side near *Herod's-foot*. On one side or other, and occasionally on both sides, of the Menheniot *lode*, the slate is interlaid by conformable beds and isolated bodies of felspathic and hornblendic rocks; which are, perhaps, connected with some, of several, similar masses containing spheroidal concretions of identical composition. The only *lode* yet wrought at Menheniot takes, on the whole, a nearly meridional range, maintains an average inclination of nearly 80° E., and varies, from six inches to four feet, in width. The *lode* of (Lanreath and Saint Pinnock) *Herod's-foot* bears slightly W. of N.—E. of S., preserves also a trifling E. dip, and is from a foot to three feet wide. Of both *lodes* the chief ingredient is quartz; often granular near the surface, but generally massive and of milk-white hue beneath; angular masses of slate and of quartzose slate, cleaved and jointed uniformly with the adjoining

(Country) rocks, are very numerous, and the crevices between them are not unusually faced with crystals of quartz, of calcareous-spar, and of galena; fluor and the sulphate of barytes abound in portions of the Menheniot *lode*, and pearl-spar is not uncommon at *Herod's-foot.* At and near the surface earthy brown iron-ore is plentiful; in many, if not in most, parts iron-pyrites is a frequent constituent; copper-pyrites and blende are disseminated through quartzose portions of the vein-stones; and ores of antimony occur in minute proportions. In the Menheniot *lode* lead-ore is more plentiful near the middle than towards the sides, and it appears more frequently in grains, and isolated masses connected by thin veins, than in large *(courses)* bodies of endlong *(shoot)* dip; but the quartzose vein-stone of the Lanreath and Saint Pinnock *lode* contains numberless small *bunches* and thick ribs of galena. In both these—as in most, if not in all, other—*lodes* the lead-ores from different parts are unequally rich in silver. The *cross (flucan)-vein* of *Herod's-foot* differs from the *cross (flucan)-veins* of *Wheal Trelawny* and *Wheal Mary Ann*—as much as the *lodes* they respectively intersect differ—in direction; whilst its width is greater than theirs. Of the *cross-veins* which intersect the *lode* at *Wheal Trelawny* and *Wheal Mary Ann* one displaces *(heaves)* it towards the *left-*—the other, generally, towards the *right-hand*, yet both displace *(heave)* it to the side of the *smaller angle.* The *cross-vein* at *Herod's-foot heaves* the *lode* also towards the *right*, but to the side of the *greater angle.* The same *cross-vein*, however, *heaves* the *lode* unequal distances at different depths; indeed it *heaves* at one spot, but simply intersects at another. During 1851 the pumping- and stamping-machinery were worked by 3 water-wheels and 10 steam-engines, whilst more than 1,000 people were employed at the mines. Profits, which amounted—at *Herod's-foot* to £49,848,—at *Wheal Trelawny* to £56,914, and at *Wheal Mary Ann* to £65,585, were from 1844 to 1868 divided amongst the shareholders.

Wheal Wrey, a neighbouring mine, continued to yield for some time considerable quantities of rich silver-ore. 699—720.

CORRECTIONS.

Page.	Line.		
3	27	*for* Nyee	*read* Nynee
6	21	,, Alaknunda	,, Aluknunda
14	10	,, Joins	,, Joints
20	6	,, *Gar*	,, *Garh.*
22	5	,, *Shealgar*	,, *Shealgarh*
29	5	,, octohedral	,, octahedral
35	6	,, *Hurchinoolee*	,, *Hurchinolee*
37	12	,, has general	,, has in general
46	16	,, found	,, collected
50	19	,, formed	,, farmed
,,	26	,, persuit	,, pursuit
53	4	,, *takles*	,, *tackles*
67	1	,, maasure	,, measure
69	28	,, XX.	,, IX.
70	19	,, even	,, ever
,,	last	,, mountain	,, surface of the mountain.
71	26	,, 9	,, 16·5—17
81	8	,, 38°	,, 35°
105	last	,, PATTISON	,, PATTINSON
121	40	,, 0·000096 to 0·000384	,, 0·000918 to 0·003673
126	last	,, §	,, ‡
138	37	,, os	,, as
142	6	,, Copiopò	,, Copiapò
146	26	,, 1786	,, 1788.
150	23	,, Copiopò	,, Copiapò
154	22	,, Brenador	,, Bramador
157	19	,, 1839	,, 1859
166	12	,, dupuis	,, depuis
169	43	,, de	,, da
173	15	,, I.	,, L.
,,	41	,, Peroxide	,, Protoxide
191	11	,, 14	,, 15
193	18	,, *foliæ*	,, *folia*
,,	27	,, Gambâ	,, Gambà
196	7	,, itself	,, alone
197	28	,, *Ibid*	,, Capt. Treloar
198	33	,, 217·321	,, 220·210
,,	34	,, 292·978	,, 293·080
199	20	,, 123·8	,, 124·2
,,	21	,, 10·08	,, 1·108
211	2	,, mica	,, talc
,,	11	,, mica	,, talcose
213	15	,, Braülien	,, Brasilien
,,	20	,, *Perrira*	,, *Pereira*
224	21	*for* iron mica-slate	*read* iron-mica slate
225	18	,, mica	,, talc
227	4	,, iron mica-slate	,, iron-mica slate
,,	7	,, Mica	,, Talc
231	29	,, 0·606944	,, 0·006944
237	25	,, Intérièur	,, Intérieur
,,	26	,, amongat	,, amongst
243	15	,, 24*	,, 245.
248	5	,, palish	,, paleish
254	20	,, II.	,, IV.
263	6	,, II.	,, IV.
290	31	,, contain	,, contained
292	44	,, 0·146	,, 0·145
343	14	,, LOUR	,, LAUR
348	14	,, two shillings & nine pence	,, nine pence
358	17	,, *Pereiro*	,, *Pereira*
405	10	,, 29° S. of E.—N. of W.	,, 29° E. of S.—W. of N.
410	32	,, 29° S. of E.—N. of W.	,, 29° E. of S.—W. of N.
422	9	,, hornblende labradorite	,, hornblende, labradorite
,,	28	,, zoolitic	,, zeolitic
435	11	,, of fine copper	,, of copper
,,	14	,, of copper	,, of fine copper
436	23	,, mosses	,, masses
472	12	,, 0·0331	,, 0·0031
,,	29	,, 0·3134	,, 0·0134
,,	33	,, *Polberrow*	,, *Polberro*
,,	37	,, 0·3063	,, 0·0063
515	1	,, *Eardistan*	,, *Eardiston*
,,	46	,, XXXIX.	,, CXXXIX.
533	15	,, jaspar	,, jasper
544	3	,, cruptive	,, eruptive
564	23	,, more highly	,, less
574	22	,, 1868	,, 1768
586	16	,, 1768	,, 1748
,,	19	,, water	,, copper
598	19	,, *lode*	,, *flucan*
603	27	,, 29° 09′	,, 28° 05′
612	17	,, southard	,, southward
616	3	,, ae mtalliferous	,, a metalliferous
718	22	,, structurc	,, structure

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Observations on Metalliferous Deposits.

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The object of this Memoir is,—to describe deposits of iron, copper, lead, chrome, cobalt, nickel, silver, and gold, associated with rocks of different ages, in various parts of the East and West Indies, North and South America, and the Continent of Europe;—to compare them with such as yield both similar and different ores—especially the ores of copper, lead, and tin—amongst formations of less varied composition in the West of England; *—and to trace the local peculiarities, which—in subordinance to general laws—have determined their distribution.

The rocks of

KUMAON AND GURHWAL,

two North-western Provinces of India, are granite; gneiss; micaceous, talcose, chloritic, hornblendic, and clay slates; limestone; and sandstone.

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* *Cornwall Geol. Trans.*, v. pp. 1—386.

The iron and copper ores, which have from time immemorial been wrought by the natives, are for the most part in the slate, especially in the clay-slate formation; but copper has also been obtained amongst the calcareous rocks; and although hitherto in small quantities, iron-ore has been found in the sandstone of the Sub-Himalayan range.

Three* small patches of granite occur,—near Dwarra Hath, at Almora, and at Deo Dhoora,—within the metalliferous district; but no ore of any kind has hitherto been found in either of them.

In texture the rock somewhat resembles the granite of Cornwall, and is rather coarse-grained; but it is sometimes traversed by veins of a variety more minutely crystalline.

Its ingredients are for the most part felspar, quartz, and mica; but near Dwarra Hath the latter is here and there replaced by talc, and schorl occasionally appears; whilst hornblende abounds towards the confines of the formation near Deo Dhoora; and porphyritic crystals of felspar are numerous throughout the formation.

As felspar is so prevalent, and as atmospheric influences are so powerful, it is not surprising that large tracts of the granite are disintegrated, and in some places even decomposed. But harder—and in general finer-grained—masses are often imbedded in the softer varieties; and, when the latter yield to degradation, the former stand out in striking, sometimes indeed in fantastic, relief.

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* Captain Herbert's Geological Map indicates a fourth near Kurn Pryag.—"*Journal of the Asiatic Society of Bengal*," XII. (N.S.) PART II., 1843.

The rocks near Dwarra Hath, divided by highly inclined joints into parallel *courses*, layers, or *slices*, which are alternately—of hard and siliceous*—and of soft, disintegrating, felspathic, and talcose granite, thus strikingly illustrate the connexion subsisting between their structure and composition.

The principal joints bear respectively about north and south,† 10°—20° S. of E. and N. of W., and the third series nearly N.E. and S.W.: the *bedding*‡—rarely horizontal—inclines sometimes one way sometimes another, but usually towards the slope of the surface.

The massive structure which prevails in the central granite, gradually passes into thick-lamellar,—but still crystalline, towards its confines; where it is overlaid by yellowish-brown mica-slate, in which talc also is often present. Isolated patches of the first rock are imbedded in the second; and of the second in the third near the limits of the respective series,§ on the mountain side, south-west of Almora. Veins of fine-grained granite—sometimes very broad—traverse the mica-slate in glens which feed the Punaar, a tributary of the Surjoo.

Except a little gold mixed with the *débris* of granite‖

* The beautiful but grotesque, and sometimes indecent, carvings on the Hindoo temples at this spot are executed in granite of the neighbourhood.

† Mr. Enys, *London and Edin. Phil. Mag.*, I. (1833) p. 322.

‡ Messrs. Schlagintweit determined the magnetic variation at Nyee Tal, in May, 1855, to be 4° 0′ 10″ E.

§ "East of the village of Dhoveet * * the rock may be called a gneiss, but "it exhibits small patches * * * * of the most regular micaceous schist, * * * "and again of the most legitimate granite."

Capt. Herbert, *Journal of the Asiatic Society*, XII. N.S. (1843) p. CXXXII.

‖ Captain Herbert obtained a specimen of granite which enclosed a speck of gold, from the bed of the Aluknunda near Kedarnath.

Asiatic Researches, Part I. (1829) p. 236.

and gneiss, in the Aluknunda at Chetoa Peepul,—in the Pindur near Kurn Pryag,—and in the Ramgunga* between Kala Bun and Gunnai, no metalliferous deposit has yet been discovered in either of these rocks. The mica-slate is seldom productive of copper, except at a distance from the granite and gneiss, and where talc is also plentiful; there, too, the veins — exclusively siliceous in the lower parts of the series — generally contain likewise notable quantities of lime.

(*a.*) At Kurrye,† near Bagesur, pearl-white talc and calc-spar alternate in thin beds, which bear about S.E. and N.W., and dip 35°—45° S.W. The calcareous strata are rarely mixed with other substances; but the talcose beds, at intervals, include kidney-shaped masses of quartz; which are sometimes tinged with earthy brown iron-ore,—are often irregularly spotted and streaked with copper-pyrites,—and now and then with purple copper-ore. Traces of the carbonate of lime and of pearl-spar occasionally appear in the quartz; but at such times copper-ore is rarely or never present in the rock; although a thin incrustation of the green carbonate of copper frequently invests the quartzose nodules.

(*b.*) Similar alternating beds of talcose and quartzose matter have been wrought at *Rai*‡ and *Bellar* in

* Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, (Agra, 1851,) p. 157. Moorcroft and Trebeck, *Travels in the Himalayan Provinces*, I. p. 7.

† Mr. Commissioner Batten, *Official Reports on the Province of Kumaon*, (Agra, 1851,) p. 313.

‡ Capt. (now Lieut. Colonel) Drummond, Journal of the Asiatic Society, No. LXXXIII. (1838) p. 935. Mr. Commissioner Batten, *Official Reports on Kumaon*, (Agra, 1851,) p. 274. *Report on the Metalliferous Deposits of Kumaon and Gurhwal. Selections from the Records of Government*, (Calcutta, 1855,) p. 9.

Gungolee, and have afforded copper-ore in both, as well as a little blende also in the latter: but the ancient works are ruinous, and nothing is now discoverable, save that the direction is in the former about 30° N. of E. and S. of W., and in the latter nearly N. and S.

(*c.*) A few specks of iron and copper-pyrites and stains of the green carbonate of copper occur in beds of talc-slate bearing 10° S. of E. and N. of W., which alternate with large and irregular masses of dusky siliceous limestone at *Goron*,* near Petoragurh. Some ancient mining works in their steep craggy slopes are now covered with rubbish.

(*d.*) The district of *Seera* consists for the most part of clay-slate,† in which traces of copper-ore are numerous.‡ Several neighbouring deposits have been examined, but continued operations are confined to one;§ which—parallel to the bedding of the adjoining rocks— bears nearly E. and W., dips N. about 50°, and is generally from two to three feet wide; though at intervals it is both enlarged and enriched by union with small metalliferous lines of quartz.

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* "Beside the bed of dolomite, beds of talc slate are found, and in this rock is "situate the copper mine, which is, however, worked on a very small scale, pro-"ducing only 50 Rupees per annum."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. (1843) p. cxvi.

† "At Seera, argillaceous schist prevails * * * of a deep iron black colour, "with straight laminæ, very hard and very brittle."

Captain Herbert, *Ibid*, p. cxix.

‡ Mr. Commissioner Batten, *Official Reports on Kumaon*, (Agra, 1851,) p. 281.

§ Mr. Commissioner Traill, *Asiatic Researches*, No. xvi. (1828) p. 137. Captain Herbert, *Ibid*, Part i. (1829) p. 243. Mr. Commissioner Lushington, *Journal of the Asiatic Society*, No. cxxxviii. (1853) p. 468. Captain Drummond, *Ibid*, No. lxxxiii. (1838) p. 936. *Selections from the Records of Government*, (Calcutta, 1855,) p. 10.

The principal ingredients are quartz and talc; but the former—frequently mixed with small quantities of calcareous matter—is by far the more abundant. Generally they are more or less mixed; though sometimes one, sometimes the other mineral almost exclusively prevails: but even then masses of the rarer are commonly imbedded in the more plentiful constituent.* Often too mere laminæ of pearl-white or pale-yellowish talc form, as it were, unctuous joints in the quartz, and give a veined structure to the whole mass. Although iron-pyrites is sometimes found in small quantities, copper-pyrites is by far the more abundant ore: both —in short and narrow veins, small lumps and scattered granules,—occur almost exclusively in the siliceous parts of the formation. The richest portions are however scarcely ores of second quality.† Small drusy cavities are not uncommon; and the crystals of quartz and of pearl-spar which line them, are sometimes coated with iron—and more rarely with copper—pyrites.

Many traces of ancient mining works yet remain near *Pokree*,‡ between Chetoa Peepul on the Alaknunda and the Snowy-range.

* "Hand specimens may be obtained in which both substances are separately "observable, as well as in mixture." Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. p. cxix.

† *Dradge-work.* Pryce, *Mineralogia Cornubiensis*, p. 234. Cornwall Geo. Trans. iv. p. 160. Mr. Henderson, *Proceed. Institution of Civil Engineers*, xvii. 1858–9, p. 16.

‡ Captain Herbert, *Asiatic Researches*, Part i. (1829) p. 236; and *Journal of the Asiatic Society*, xii. n.s. (1843) p. xcvi.; Mr. Commissioner Traill, *Asiatic Researches*, xvi. p. 130; Lieut. Glasfurd, *Journal of the Asiatic Society*, No. xc. n.s. (1839) p. 471; Mr. Commissioner Lushington, *Ibid*, xii. n.s. p. 455; Mr. Reckendorf, *Ibid*, xiv. p. 471; Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 152; *Extracts from the Records of Government* (Calcutta, 1855), p. 4.

The rocks of the district are talc, clay, and chlorite slates; and copper is found in them all.

(*e.*) At *Talapoongla* the prevailing formation is brownish talc-slate, occasionally alternating with thin homogenous laminæ of a lead-blue colour and silky lustre.* Flakes of copper-pyrites,—now and then as much as one-eighth of an inch in width, but seldom thicker than paper, or more than an inch or two in length, and usually much shorter,—occasionally interlie the other ingredients and form an intregal part, especially of the lead-coloured rock. These laminæ of ore occur for the most part in a bed four or five feet in width, parallel to the adjoining rocks, which are almost exclusively talcose. They all exhibit many small twists and contortions, but their general *strike* is about 10° N. of E. and S. of W., and they dip N. about 10°. Two series of joints, bearing respectively about E. and W., and 15° E. of S. and W. of N., traverse indifferently the earthy and the metallic members of the series.

(*f.*) The *Danda* mine is situate near the top and the *Thala* at the bottom of a rugged and precipitous mountain-side; of which the ridge is talc-slate, the middle chlorite-slate, and the base of both in thin alternating layers.

The same *strike*—about E. and W.; the same dip—N. 30°; the same single series of joints—bearing E.N.E.

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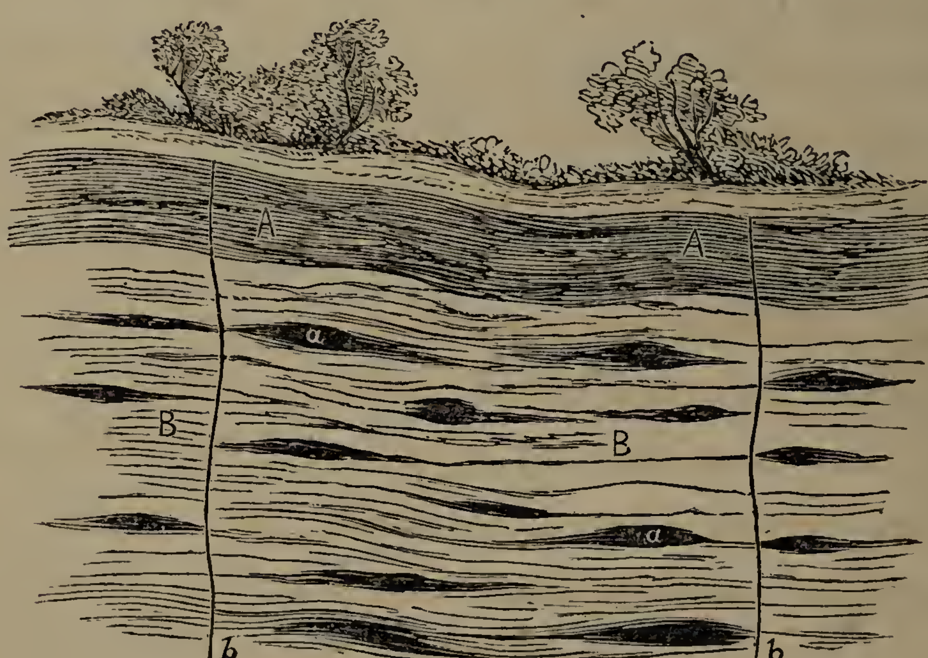
* "Chloritic schist * * * continues to near Pokree, occasionally giving place "to talcose schist, occasionally to talcose quartz rock. Near some of the old "galleries of the copper mines worked here are beautiful specimens of an emerald "green straight laminar slate with high lustre."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. p. xcvi.

and W.S.W.; and the same fissile structure, are common to both.

The chlorite-slate is at intervals interlaid with irregular lenticular beds of quartz, few of which exceed three feet in length or six inches in thickness, and most of them are much smaller. Chloritic matter is sometimes thinly diffused through the quartz, and it is also spotted with iron sparingly mingled with copper-pyrites, from which a slight efflorescence occasionally incrusts the surface.

Fig. 1. DANDA MINE. *Section.*



A Talc-slate. *a* Metalliferous quartz.
B Chlorite-slate *b* Joints.

These beds of metalliferous quartz,—owing perhaps to some play of affinities having induced differences of composition or structure,—are larger and more numerous in the centre than towards the sides of the *slices* into which the slates are divided by their nearly vertical joints. Generally, indeed, each slice contains its own system of beds, which are thickest towards the middle

and die out as they recede. Although in adjoining masses the beds are seldom on the same plane, one is occasionally prolonged into contiguous slices; even then, however, it dwindles at the joint and enlarges in the interior.

(*g.*) About twenty years ago* the *Chowmittee* mine—the only one now worked in the neighbourhood,—was selected for an experiment at the expense of Government; and thus,—though neither the most interesting nor the most productive,—and though the trial was unsuccessful,—it has become the most generally known copper-mine in the North-West Provinces.

Two galleries were opened, one above another, by native miners; and more recently under European superintendence, three others at different, but less elevations; the upper of these is, however, the only one now existing. All five galleries have followed the contact of differently coloured rocks; which, bearing about 15° E. of S. and W. of N., and dipping 50° N. of E., exactly coincides with the cleavage of both. The laminæ of the lower rock,—of homogeneous texture, leaden hue, and silky lustre,—are interlaid by minute scales of yellowish talc; whilst the upper, of pale-buff passing into lemon colour, is almost entirely talcose: their structure, alike, is extremely fissile. At and near their junction both rocks,—but the lower especially,—are interlamellated sometimes with copper-pyrites†, some

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* Mr. Commissioner Lushington, *Journal of the Asiatic Society*, XII. N.S. p. 456; and *Official Reports on Kumaon*, p. 369.

† *Ante*, p. 7.

times with purple copper-ore, and more rarely with both. The plates of ore are generally about the thickness of paper, but at times they widen to one eighth of an inch, and lumps as big as a filbert are occasionally, though seldom, found; now and then as much as six—they are commonly less than two—inches in length and breadth, and many are still smaller. Short, thin, and irregular beds of quartz, at times mixed with earthy brown iron-ore *(gossan*)*, frequently interlie the slates in the same neighbourhood; and are not only transfused with ores similar to those of the metalliferous laminæ they touch, but are spotted with vitreous and black copper-ore; and incrusted, sparingly with the blue,—and more plentifully with the green—carbonate of copper also. The general produce, however,—inferior in quality to that of *Seera*,†—would not be considered as ore even of second class‡ by English copper-miners.

(*h.*) The *Rajah's*,§ the *Thala*, and other small copper mines have been from time to time opened in the same neighbourhood, either by the natives or by Government; but as some resemble those already described, others are closed, and all are now abandoned, further mention of them seems unnecessary.

(*i.*) The high and picturesque cliff which forms the

* Cornwall Geol. Trans. v. p. 204.

† *Ante*, p. 6.

‡ Pryce, *Mineralogia Cornubiensis*, p. 236; *Cornwall Geol. Trans.* IV. p. 166; Mr. Henderson, *Proceedings of the Institution of Civil Engineers*, XVII. (1858) p. 16.

§ Mr. Commissioner Lushington, *Journal of the Asiatic Society*, XII. N.S. p. 460; and *Official Reports of Kumaon*, p. 373.

left bank of the Ramgunga, at *Al Agur* mine,* some three miles north-west of Lohba, an ancient native fort now in ruins, consists of dark-green chlorite-slate, of which the cleavage-planes bear about S.E. and N.W., and dip S.W. 30°. Everywhere more or less siliceous, the almost exclusively quartzose character of one bed, cropping out in the precipice, is varied only by the interposition of some slaty laminæ, which, conforming to those of the adjoining rock, thus impress a veined or lamellar structure on the whole. Narrowing from ten feet at the surface, to about three at fifteen fathoms deep, the slate, a conspicuous ingredient in the shallower parts of the bed, gradually disappears in the deeper; and ochrey pale-brown iron-ore, of but occasional occurrence at first, becomes at length abundant. The green carbonate is the only ore of copper found in the upper part of the formation; but, though seldom or never entirely absent, it is in a great measure replaced by vitreous and purple ores towards the bottom of the mine.

(*j.*) The mine of *Dhunpoore*,† about ten miles south-west of Kurn Pryag, is wrought in the northern extremity of a mountain range perhaps five thousand feet above, and immediately south of Chetoa Peepul on the Aluknunda.

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* Mr. Deputy Becket, *Selections from the Records of Government*, N.W.P. Part XIII. (1853) p. 73.

† Mr. Commissioner Traill, *Asiatic Researches*, XVI. p. 137. Captain Herbert, *Ibid*, (1829) Part I. p. 241; *Journal of the Asiatic Society*, XII. N.S. p. C. Mr. Commissioner Lushington, *Ibid*, p. 463. Mr. Reckendorf, *Ibid*, XVI. (1845) p. 474. Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 154. *Extracts from the Records of Government*, (Calcutta, 1855,) p. 6.

The slate rock of the neighbourhood, generally blue though sometimes buff or brownish, has mostly a silky lustre, and—by the interposition of thin, crooked, and irregular quartzose beds—is much contorted, and extremely fissile.* The quartz is mixed with calcareous matter, and—though in smaller proportion—the slate is seldom destitute of it.

The laminæ bear about E. and W.; but they are so distorted that it is scarcely possible to assign them an amount or even a direction of dip.†

A bed of siliceous limestone,‡ sometimes greyish-white, sometimes pink, but usually of a pale buff colour, interlies the slate; though slightly undulating in different directions, and seldom quite level for any great distance, it may—on the whole—be considered nearly horizontal; its thickness is generally about a foot, but under special circumstances—to be mentioned presently—it enlarges, for short distances, to fifteen, and occasionally even to twenty, feet.

The slate and limestone are alike traversed by two sets of joints; one—nearly parallel to the *strike* of the lamination—bears about E. and W.; the other between

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* "In the ascent to Dhunpore quartz rock * * * passes * * * into a very "thin slaty rock of a yellowish colour, * * * composed apparently of quartz "with some talc. The laminæ of this are not above a tenth of an inch in thick-"ness * * * * are often bent and curved. * * * It passes into argillaceous "schist * * * variously mixed with limestone more or less pure."
Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. p. xcix.

† "The rock in the neighbourhood of Dhunpore is distinguished for its "peculiar shattered and fissured aspect, no trace of stratification being obser-"vable except on the great scale. The irregularity of the strata is great, and "the change of dip frequent."—*Ibid*, p. c.

‡ "This * * is evidently connected with the siliceous limestone on the Dhobree "side" (of the mountain), "in which also a mine is worked, but the produce is "inconsiderable."—*Ibid*, p. c.

N. and S., and 10°–15° E. of N. and W. of S.; both series are highly inclined, and in bearing and dip are subject to slight though frequent flexures, sometimes towards one—sometimes towards the other—side. Generally speaking, the joints exhibit a mere contact of two smooth faces; in some places, however, they enclose *slices* of the rock adjoining, in others thin plates of purple-copper-ore, and often the ore and the rock are mixed. The non-metallic ingredients, thus included, are divided into somewhat lenticular masses by

Fig. 2. *Section.*

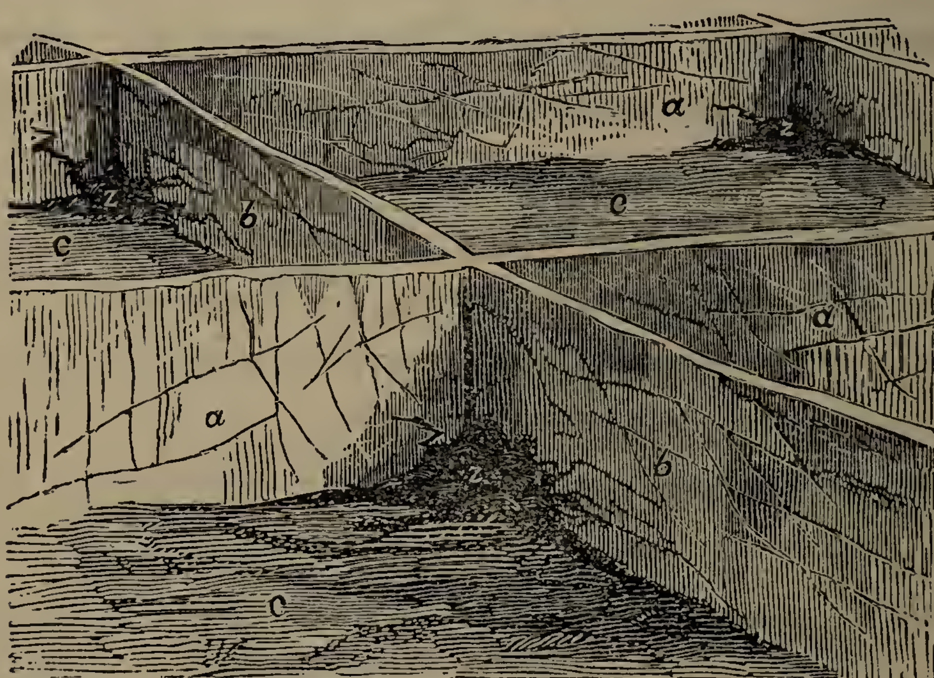
Internal Structure.

the undulation and interlacing of numerous minor joints, which are often lined with clay, and marked with striæ, sometimes parallel sometimes diverging, but rarely preserving an uniform direction either on opposite sides of the same mass, or even on the same surface, for more than a few inches.* At these intersections the ore is also usually marked with slickensides.† These enlargements though—on the nearly N. and S. or normal joints especially—numerous are seldom of great extent; for the undulation which in one direction separates the faces, in the opposite brings them again together. A third set of joints bears about 30° E. of S. and W. of N., but it is very slightly developed.

* Cornwall Geol. Trans. v. pp. 53, 172; *Table* XVIII.
† *Ibid*, p. 181; *Table* XXIX.

The joints of both the principal series widen and become more metalliferous as they approach the nearly horizontal bed of siliceous limestone; and small as they are above, they then often reach a width of six inches, and are occasionally still larger.* The characteristic deposits of ore occur, however, in neither of the two systems of transverse and nearly vertical master joints;

Fig. 3. DHUNPOORE MINE.



a Joints E. and W.
b Joints E. of N. and W. of S.
C Bed of siliceous limestone.
Z Masses of copper-ore, at the contact of the joints with limestone.

nor even where they merely intersect; but at those points only where such intersections meet the upper face of the calcareo-siliceous bed,† which is generally thicker at these places than elsewhere. The rock sur-

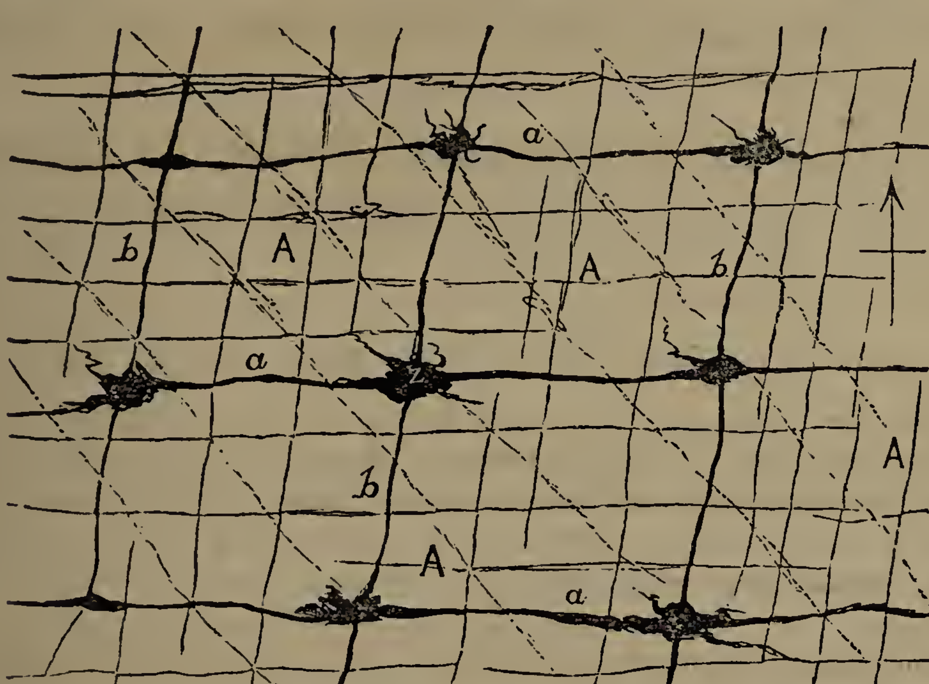
* "The seams of ore are said to be one foot thick at times, but generally they "are less than one inch thick, and anything more than that is considered a "prize by the miners."

Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 464.

† "Above" (the horizontal vein the ore) "dwindles away to the size of a "reed."—*Ibid*, p. 464.

rounding these double intersections is often for some distance richly charged with purple copper-ore and—less frequently—with copper-pyrites; from which veins—more pyritous than the main body—penetrate, as well the limestone as the adjoining slate, in all directions. This impregnation extends—in extreme cases—as much as twenty-five or even thirty feet, but generally less than half that distance; and in rare instances no increase either of size or produce accompanies these double contacts; but neither joint nor neighbouring rock is then metalliferous. With these unimportant exceptions therefore, whether we approach the limestone on the line at which the two systems of joints intersect, or the intersection of the joints on the plane of the limestone, the width and riches of the joints simultaneously increase. As the joints of each system

Fig. 4. DHUNPOORE MINE. *Plan.*



A Calcareo-siliceous slate. *a* Joints E. and W.
Z Masses of copper-ore. *b* Joints E. of N. and W. of S.

preserve a parallelism amongst themselves, and the

systems are nearly at right angles to one another, whilst the ore occurs chiefly at their intersections; the formation has somewhat the appearance of a *chess-board* with spots at the angles of each division, which is in fact rather rhombic than square. From the same point therefore, the little masses of ore present on one view a parallel, on the other a transverse, disposition. This symmetrical arrangement on a still larger scale has long been recognised in Cornwall, in the proverbial phrase of "ore against ore."*

The limestone as well as the slates above and beneath it have been long and carefully examined by native miners; but as the upper have been the most productive —they have also been the most constantly and extensively wrought—parts of both formations; to them, therefore, these remarks exclusively relate.

I cannot leave *Dhunpoore* without mention of the view it commands,† which—once seen—can never be forgotten.

More than five thousand feet beneath, the Aluknunda fresh from the snows rushes through a yawning chasm

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* Mr. Carne, Corn. Geol. Trans. III. p. 78; *Ibid*, v. pp. 87*, 215, 233.

† "The view from the crest of the Dhunpoor ridge is beyond description "beautiful and majestic. The great castellated peaks of Budrinath rise directly "in front of the spectator, and on either side of these as far as the eye can reach, "appears a long succession of other snowy peaks, varying in form and altitude; "but all and each surpassingly grand and sublime. Gungotri, Kedarnath, and "Budrinath to the left, Trisool, Nundadevi, Purychoola, and Kylas to the "right, fully merit the title bestowed upon them by the Shastra, of 'Mountain "Kings.'"

Mr. Commissioner Lushington, *Journal of the Asiatic Society*, XII. N.S. p. 463.

"The Dhunpoore range is noted for its magnificent scenery."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 154.

towards the low-lands; where, soon abating its fury, it quietly meanders amidst smiling meadows.

The sugar-cane flourishes, and plantain, orange, pomegranate, apricot, and other fruit trees thrive in many warm valleys and deep secluded glens, amid the broken mountainous tract, which rises in successive ridges from the river to the limits of vegetation; and, though still the haunt of tigers, bears, and other beasts of prey,* is often richly wooded, and sprinkled with terraced corn-fields, pastures, and villages.

Seemingly almost within hail, but really twelve or fifteen miles distant, the forests are succeeded by snows; over which—as far as the eye can reach—the view extends not only to the highest peaks of the Himalayas—the boundary of British India—and through the passes between them into Thibet, on the north; but far beyond the frontier of Nepal on the east, and to the ridges of Jumnotree on the west. The general elevation of the region is from twelve to twenty thousand feet; though its highest ranges exceed twenty-five thousand.† A few steeps and cliffs of naked rock alone pierce the perpetual snows, which cover the thousand square miles of this awful but magnificent solitude.

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* "Owing to the situation of some of the villages near the forest, and the "difficulty experienced by the few inhabitants in preserving themselves and their "crops from the ravages of wild beasts, a decrease of the Government demand "* * * was found necessary."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 153.

† "In a line of 500 miles two summits are found exceeding five miles in "perpendicular height, * * * connected to appearance by a regular series of "peaks of very little inferior elevation. * * * If we confine ourselves to 21,000 "feet, we may find a connected line of such peaks extending through a distance "of 1,000 miles."

Captain Herbert, *Journal of the Asiatic Society*, XII. N.S. p. XXII.

(*k.*) Near *Tarag-ke-Tal,** a small lake which supplies a tributary to the Ramgunga about two miles east of Gunnai, small quantities of copper-ore occur in a cliff, the brow of which is grey siliceous limestone, and the base of mottled grey and white calcareo-siliceous slate; the *strike* of the beds is S.E. and N.W., and their dip —S.W. about 30°. One series of joints is parallel to the slaty structure, another bears 10°—15° W. of N.; both are faced with unctuous clay, and their outcrop is incrusted with calcareous stalagmites, occasionally tinged with the green carbonate of copper. The metalliferous bed— eight or nine feet in thickness—is parallel both in bearing and in dip to the adjoining slate, and differs from it only in being more siliceous towards the middle, and more calcareous at the sides. The quartzose ingredients are thinly spotted with copper-pyrites, and small quantities of the green carbonate of copper occur amongst the calciferous slate beneath.

Copper-ore has been wrought in a few other localities; but it is even less plentiful in them, than in those already described.

(B.) *Iron-ore* abounds in many parts of both Provinces; but hitherto it has not been found as deep as the gneiss formation.

The district of Chowgurhka exhibits many traces of ancient mining, and a few iron-mines are still wrought there; they are, however, so far apart that the metalliferous deposits have been traced neither

* Mr. Commissioner Batten, *Official Reports on Kumaon,* p. 317. *Extracts from the Records of Government* (Calcutta, 1855), p. 8.

throughout the district, nor even from one mine to another.

(*a*.) The furnaces at Nadhoolee are in great measure, and those of Maarum are entirely,—supplied with ore from the *Sahloo* mine, an open-work in a massive talcose rock near Dhoora Devi.* Operations have extended to a depth of nine fathoms, and—without having reached the lower *(foot)-wall*—to a width of nine or ten feet, on a bed which bears nearly N. and S.,—dips E. 50°—58°,—and consists principally of compact but partly also of earthy-brown iron-ore; mixed with quartz, in greater or smaller proportion throughout,† especially towards the interior. Lumps of copper pyrites, sometimes associated with purple copper-ore, are—at intervals—imbedded in the iron-ore, in which likewise drusy cavities are occasionally lined with the rhomboidal arseniate of copper. The quantity of copper-ore is however so small that it has attracted but little attention.‡

(*b*.) At *Agur*,§ in the same district, large isolated

* On the edge of a small grassy glade, a temple,—three tall sculptured stones, —a slate *cromlech*,—and one of the large iron-chain *swings*—often seen in places held holy by the natives, are shaded by a sacred grove of noble Deodars *(Pinus Deodara)*, under which I encamped at Dhoora Devi.

† Professor Warington W. Smyth, *Quarterly Journal, Geol. Soc.* xv. p. 107.

‡ *Extracts from the Records of Government* (Calcutta, 1855), p. 22.

§ A temple of rude workmanship and several small cromlechs of slate have been set up in the oak *(Quercus semecarpifolia)* forest at Agur. Some of the cromlechs are horizontal, but others are inclined at angles of from thirty to forty degrees. "The flat-topped cromlechs are used indifferently as altars or as seats; "for though sometimes covered with offerings of rice and flowers, the natives "just as often sit and rest their burdens on them. The inclined ones generally "rest on the ground at one end, and are propped at the sides in such a manner "that about two-thirds of the circumference is sheltered. Under these are sus-"pended small rudely made iron lamps, which generally contain oil, but are "lighted only when religious rites are solemnized."

Proceedings of the Royal Institution of Cornwall (1855), p. 20.

Extracts from the Records of Government (Calcutta, 1855), p. 23.

masses of compact—and considerable quantities of scaly—brown iron-ores occur in a matrix of talc about two feet in thickness; which—coinciding with the structure of the adjoining talc-slate—bears nearly S.E. and N.W., and dips S.W. 15°—20°.*

(*c.*) At *Luttea Gar*, an abandoned mine in the same neighbourhood,† the refuse—consisting of cellular and friable quartz, mixed with earthy-brown iron-ore *(gossan)*‡—contains stones of copper-pyrites and is spotted with the green carbonate of copper.

(*d.*) The *Bunna* mine near Ockulgurh is wrought for some fifteen fathoms in length, and to about forty-five in depth, from four openings—one above another —in the side of a mountain which bounds the Punaar valley on the north. The rock—consisting of pale yellowish talc and quartz—is of thick lamellar structure; its beds—like those of the metalliferous deposit which interlie them—bear about 16° S. of E. and N. of W., and dip 40°—70° S. The ore—exclusively specular-iron—is but slightly mixed with the adjoining ingredients,§ and is from ten to twelve feet in width. Towards the bottom of the mine it is divided into two —of which the lower portion is much the thinner—by a *(horse)* mass of rock, similar in composition to that of the *(walls)* sides, and coincident both with it and with the scales of ore in lamination. Eastward this

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* *Extracts from the Records of Government* (Calcutta, 1855), p. 23.

† *Official Reports on Kumaon*, p. 313. ‡ Cornwall Geol. Trans. v. p. 204.

§ The only difference between this formation and the *Jacotinga* of Brazil, is in the former containing neither Manganese nor Gold, whilst the latter affords both.

included slice of talcose rock maintains a tolerably uniform thickness of between two and three feet; but westward it becomes gradually narrower and ultimately dies out, as it also does upward,—disappearing at some distance from the surface.

Somewhat lower in the series the rocks are almost entirely quartzose, and are then largely used in the construction of furnaces.

(*e.*) The district of Agur,* long the most extensive field of mining industry in Kumaon, though still rich in iron-ore, is now reduced to comparative insignificance, by a thriftless destruction of the forests, which has at length deprived the smelters of fuel. The prevailing rock is talcose-slate; always more or less quartzose,† on the north; but often alternating with layers of clay-slate towards the south. Although the beds have a

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* "The villages of Agur, whence the inhabitants are called Agurees, belong "to the tribe of *Sones*, whose especial avocation is, the working of the iron mines "and preparing the ore, not only of the Lohakote ridge itself, but throughout "the province. They are Soodras by caste, and will not labor at the actual work "of *lohars* or *blacksmiths*. * * * The Agurees remain at home from May till "November, and during the rest of the year they and their families are to be "found at the several mines, some of the best of which are to be found in Ram-"gurh itself. The main body, after sowing their wheat and barley, however, "collect at Khetsaree, where the mild climate and cheap food, besides the plentiful "ores, hold out great attractions. * * * The terms on which the lessees of the "mines are obliged, in the absence of competitors, to engage the *Sones*, are "highly favourable to the latter."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 303.

† "Below the pass we have a white schistose quartz rock of rather arenaceous "composition, * * * which evidently contains talc, * * * and perhaps some "felspar."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. (1843) p. xciv; *Asiatic Researches*, i. p. 255.

"Rich mines of red hematite are found and worked in the quartz rock."

Captain Strachey, *Quarterly Journal of the Geol. Soc.*, vii. (1851) p. 298.

prevailing direction of 10°—20° E. of S. and W. of N.; portions of their numerous short and abrupt flexures bear nearly at right angles to the general *strike*. Within a distance of about six miles the iron-mines of *Shealgar*, *Guarocoolee*, *Lusghanee*, *Nutoa Kanh*, *Gallà*, *Dhoora Kanhi*, *Capuà*, *Choocootà*, *Bunnà*, *Purturburà*, and others, are wrought—sometimes as much as twenty fathoms deep, but generally much less—on the same bed, or system of beds of ore,—which,—oblique, as well to the mountain-range it traverses, as to the glens and deep ravines which furrow its sides,—seldom differs widely from the strata in general direction, though they are rarely quite parallel* except where they touch. For a short distance on either side of the iron-formation the rocks cease to maintain their ordinary bearing; and approximating more and more closely to its *strike* and dip as the distance between them diminishes, they assume—at length—an almost perfect parallelism at their contact. But small as the extent of this parallelism in each case necessarily is, every rock of the district assumes in its turn a similar position; and whether the iron-formation be approached on one side or other in the normal direction of the strata, their deflected portions which adjoin it,

Fig. 5. *Plan.*

a Bed of iron-ore.

* Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. (1843) p. xciii.

are—in the apt mining language of Cornwall—found on the *left-hand*.*

The rich repository of *Nutoa Kanh* the metalliferous deposit consisting in great measure of specular iron-ore, mixed with some quartz, and a little talc, is for some distance divided into four separate beds by lenticular layers of quartzose talc-slate, similar to that on either side. These however soon die out, and within a few fathoms the beds of ore re-unite, both in length and depth.

The mutual relations, universal between metalliferous deposits and the rocks which adjoin them,† are seldom so manifest as they are in this district. The iron formation—though exhibiting many inflections—maintains a general direction about 25°—40° E. of S. and W. of N.; and whilst partaking—more or less—the

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* Mr. Thomas, *Report on a Survey of the Mining District of Cornwall* (1819), p. 22, Note. Mr. Carne, *Cornwall Geol. Trans.*, II. p. 86. My own Papers, *Ibid*, V. p. 5.

† Carew, *Survey of Cornwall* (1602); Price's Edition, p. 10; Lord De Dunstanville's Edition, p. 33. Borlase, *Natural History of Cornwall* (1758), p. 147. Pryce, *Mineralogia Cornubiensis*, p. 94. M. Jars, Voyages Métallurgiques, III. p. 190. Dr. Thomson, *Travels in Sweden*, pp. 218, 220. Dr. Berger, *Geol. Trans.*, I. p. 164. Mr. Carne, *Cornwall Geol. Trans.*, III. p. 78. Dr. Boase, *Ibid*, IV. p. 441; and *Primary Geology*, p. 168. Prof. Sedgwick,—Address to the Geological Society,—*Phil. Mag. and Annals*, IX. (1831), p. 284. Mr. Taylor, *Reports of the British Association*, II. (1833) p. 23. Mr. Burr, *Mining Review*, No. VIII. (1836) p. 218. Mr. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836), p. 84. Mr. Bakewell, *Introduction to Geology* (4th Edit.), p. 430. Dr. Macculloch, *System of Geology*, I. p. 386. Professor Phillips, *Encyclop. Metrop. Geology*, p. 772; *Encyclop. Britan.* (reprint), p. 272; *Cabinet Cyclop.*, II. p. 134. Sir H. T. De la Beche, *Geological Manual* (3rd Edit.), p. 492; *Researches in Theoretical Geology*, p. 218; *Report on Cornwall, &c.*, p. 335. M. Domeyko, *Annales des Mines* (4me série), IX. p. 437. M. Moissenet, *Ibid* (5me série), XI. p. 418. My own Papers, *Phil. Mag. and Annals*, X. (1831) p. 460; *Edin. New Phil. Journal*, XXII. pp. 156, 271; *Annals of Electricity*, I. p. 124; *Annales des Mines*, XI. (1837) p. 586; Cornwall Geol. Trans., V. p. 189.

mineral composition of every rock in the district, as it touches each in succession, it imparts at the same time its characteristic colouring to the adjoining portions of all. Nor are the changes in its metallic, less marked than those of its earthy, ingredients; for yielding the micaceous variety of specular iron-ore only whilst amongst the quartzose talc-slates of *Nutoa Kanh* and other mines north of the Ramgurh or Khurna valley; in the alternating talc and clay-slates of *Bunnà* and *Purturburà* on the south, the brown and magnetic ores alone prevail. But, though this bed has been examined in every part of its course; in common with all other metalliferous deposits, it is rich at intervals only. Its different connexions and changes are however briefly shown in the accompanying columns. (*Table* I.)

The thinly laminated rocks which overlie the great iron-formation consist, for the most part, of quartz and micaceous specular iron-ore in almost innumerable alternations. Gradually, however, the latter is replaced by chlorite or some kindred mineral* of bluish-green colour; and at the same time, lime becomes an ingredient.†

(*f.*) At *Pahlee*, near the village of Ramgurh, a glossy blue homogeneous slate is interlaid by a bed of micaceous specular iron-ore about two feet in thickness,‡ which bears about S.E. and N.W. and dips towards the N.E., but whether it is independent of or subordinate to the great iron-formation of the district, has not been ascertained.

(*g.*) About two miles from the mines of *Bunna*§ on the east, *Agur*‖ on the west, and about twice that distance from the nearest mine in the Ramgurh or Agur district,¶—all in rocks more or less talcose,—the mine of *Pahlee***—the second of that name—is wrought, in clay-slate, within the district of Kalee

* "Below the pass, we have a white schistose quartz-rock of rather arenaceous "composition."

CAPTAIN HERBERT, *Journal of the Asiatic Society*, XII. N.S. p. XCIII.

† "It is exchanged for a very hard bluish-grey rock, with much the external "aspect of limestone, but non-effervescent, or very rarely so, and in a low de-"gree."—*Ibid*, p. XCIII.

‡ "At Ramgár, on the road from Bhamáori to Almorah, the red hœmatite "passes into the variety called scaly iron-ore, consisting of loosely cohering "glimmering particles of a steel-grey or iron-black colour, strongly soiling and "feeling unctuous to the touch. This bed, though distant many miles from that "at Dhaniakót, is, I think, connected with it beneath, and the two form one and "the same deposit." CAPTAIN HERBERT, *Asiatic Researches*, I. p. 254.

§ *Ante*, p. 20. ‖ *Ante*, p. 19. ¶ *Ante*, p. 21.

** *Extracts from the Records of Government* (Calcutta, 1855), p. 21.

Kumaon, on one of the upper tributaries of the Punaar.

Dipping, as the bed of ore dips, 18°—20° N.W., and parallel in direction as well to it, as in great measure to the undulations of the surface, the laminæ bear in some places 10° N. of E. and S. of W., and in others about N.E. and S.W. The general texture of the rock is homogeneous, and the colour dark blue; occasionally however it is interfoliated with thin plates of quartz and ferruginous clay, and has then a chocolate-brown hue. The rock and the ore are alike traversed by two series of joints; one bearing nearly S.E. and N.W., the other 25° E. of N. and W. of S.

Though many acres of the surface exhibit numerous traces of ancient mining, operations are at present limited to the neighbourhood of two shafts, which have been sunk to a depth of about twelve fathoms, on a bed of compact brown iron-ore, often mixed with quartz, and frequently also with slaty matter; its thickness varies from a foot and a half to three feet, and may average about two feet. Thin laminæ of iron-ore interlie the rock on either side of the principal bed, and in them small quantities of copper-pyrites are occasionally found.

(*h.*) At *Mungla Lekh*,* in the district of Dheeaneerow, innumerable indications of mining occupy an area of perhaps half a mile square in the clay-slate, which

* "There are iron-mines at Munglalekh in Dheeanee-row, of which the ore is "said to be the best in the province; certainly the iron made from it is most "esteemed by the plains traders."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 296. *Extracts from the Records of Government* (Calcutta, 1855), p. 20.

succeeds the mica slate penetrated by granite-veins,* subordinate to the granite of Deo (Devi) Dhoora.†

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* *Ante*, p. 3.

† "The temples and other objects of Pagan worship on the summit of Deo "(Devi) Dhoora, a granitic mountain some miles south-east of Almora, are "considered of peculiar sanctity, and much visited by Hindoo devotees. With- "out,—but very near,—the shorter sides of an oblong square enclosure, sur- "rounding the two principal temples, which face opposite points, as well as in "front of a smaller place of worship, about a furlong to the south-east, three "large blocks of granite, respectively about four feet, two feet and a half, and "one foot above the general surface, afford tolerably level spaces of several feet "area. The upper face of each exhibits five pits or basons of about a foot in "depth and six or eight inches in diameter; their brims are sharply cut, their "sides are perfectly smooth, and no trace of disintegration appears in either of "them. Without symetrical positions and at irregular distances from each "other,—they are evidently artificial; but neither the priests of the temples nor "my native attendants were disposed to satisfy enquiries as to their uses, or "indeed relative to their religious rites generally.

"The small south-eastern place of worship,—about twelve or fourteen feet "long, by perhaps eight in breadth and height,—differs but little from the "ordinary dwellings of the natives. It is divided within by railings into two "unequal parts, of which the larger is for the priests and the smaller for their "congregation. A closed cell was observed on one side, and a quantity of ashes "on the floor of the former; the latter was empty.

"When this district was overrun by Mahomedan conquerors, many of the "Hindoo temples were destroyed, and most of their idols were broken; the sacred "edifices are therefore now frequently made of wood. One of these wooden "buildings has been erected within the holy precincts at Deo Dhoora, which are "however still strewed with richly-cut stones of the original temple. One ancient "place of native worship there, the most ruthless destroyer would find it difficult "to mutilate. Two masses of granite of more than fifty feet square each, por- "tions of a romantic cairn, rise from the verge of a precipice: apart downward, "they touch above, and thus form a stupendous natural portal to a small cavern "in the rock. With admirable adaptation, a long flight of broad rough steps "leads to this frowning entrance: but the expectations raised at its Cyclopean "porch are disappointed by the straitened dimensions of the temple within; which "is lighted only through the doorway and through crevices in the rocky roof. "Rice and flowers were offered on a low stone altar before the mutilated idol— "a semi-human figure with the legs folded beneath—a representation of some "incarnation of the Hindoo deity. A sacrifice had been offered by one of my "native attendants but a few minutes before I entered the temple; and it was "not without horror and disgust that—on becoming accustomed to the twilight "within—I found myself steeping in the blood of the victim which spattered the "sides, and formed a pool on the floor. The remains of several small granite- "built shrines still exist on the same rocky surface in which the rock-basons

Sometimes of a dull pale—sometimes of a glossy dark-blue colour, but generally more or less mottled with both, the rock is of thick lamellar structure; its beds, like those of ore which interlie them, bearing about E. and W., and dipping 18°—40° N.

Resembling the neighbouring rock, as well in composition and structure, as in bearing and dip; three layers of slate,—the widest about five,—and the others perhaps two—feet in thickness; alternate with four parallel bands of ore; the largest of them nearly six,—the others—varying from a foot and a half to three—

"have been sunk near this natural temple, and each contains a fragment of an "idol.

"Close at hand, also, a stone of about ten tons in weight, evidently once a "logan-rock, lies overthrown; and at least four other similar rocks,—which "equally bear traces of having been purposely upset, crown wild picturesque "granite cairns in the neighbourhood. An isolated granite rock of perhaps "twelve or fourteen feet in height and six feet in diameter on an elevated part "of the mountain, about a mile from the temples, is still an object of worship.

"In front of the small south-eastern place of worship, and very near the rock-"basons, are two cromlechs; the larger—an oblong square of five feet in length "and two feet and a half in width is supported horizontally at rather less than "three feet from the ground on six vertical stones:—the smaller—a triangle of "perhaps two feet and a half side is sustained at an angle of about thirty degrees "from the horizon; by props at the two inclined sides and by one corner resting "on the ground; the space beneath thus partially sheltered from the wind for "perhaps two-thirds of its circumference contains a small iron lamp of rude and "primitive workmanship. Whatever the rocks in their respective neighbour-"hoods, the cromlechs are always of slate. In Cornwall, on the contrary, there "is but a single cromlech (of schorl-rock—*Capel)* which is not of granite; and "but two—the Trethevy-stone near Liskeard and the Coyte near Saint Columb—"beyond the limits of the granite formation.

"One of the large iron-chain *swings* so often found in the holy-places of the "natives (*Ante*, p. 19, note), hung over the basoned-rock in front of the principal "temple, and was in constant requisition by the worshippers.

"It is vain for me to offer an idea of the rich, wild scenery of the cairn which "forms the roof of this singular temple; enormous blocks of granite of the "most picturesque forms are piled in the strangest confusion: flowering pear-"trees, blossoming walnuts, and noble gnarled oaks spring from the crevices, "and patriarchal deodars overshadow the whole."

My own paper, *Proceedings of the Royal Institution of Cornwall* (1855), p. 19.

averaging some two feet in width. These are wrought, in four separate mines, to depths of from about four—to fourteen—fathoms. The ore most prevalent in all these beds is the micaceous variety of specular iron, in which octohedral crystals of oxydulated iron-ore are frequently imbedded; and, in either parallel—though subordinate—layers, or irregular dispersed masses,—brown iron-ore—often mixed with quartz, is also abundant.

(*i.*) The most extensive field of Mining industry in Kumaon is on the north-eastern side of Kotelar and Khetsaree,* valleys in the division of Palee Puchaon; which, commencing—the one near Dwarra Hath on the south-east,—the other at Simul-khet† in Ghurwal on the north-west,—points sixteen miles apart,— meet, and discharge their tribute to the Ramgunga, at Gunnai.

A small extent of granitic gneiss and brownish-buff coloured micaceous slate‡ connects the granite of

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* Captain Herbert, *Asiatic Researches*, I. (1829) p. 255; *Journal of the Asiatic Society*, XII. N.S. p. CIII. Lieut. Glasfurd, *Ibid*, No. LXXXIII. (1838) p. 473. Mr. Commissioner Lushington, *Ibid*, XII. N.S. p. 469. Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 317. Mr. Deputy Collector Beckett, *Selections from the Records of Government*, N.W.P. (Agra) Part XIII. (1853) p. 67; *Extracts from the Records of Government* (Calcutta, 1855), p. 23.

† Pilgrims to Badrinath, Kedarnath, and other mountain shrines hang innumerable small shreds of cloth on the trees at Simul-khet, Ghagur, and other "passes," where the traveller northward comes suddenly on magnificent views of the snowy range. Votive offerings of the same strange kind are left on the shrubs near Madron well, to this day by parents who still bathe their weakly children there in the spring.

Proceedings of the Royal Institution of Cornwall (1855), p. 21, Note. Mr. Blight, *Ancient Crosses and other Antiquities in the East of Cornwall*, II. p. 71.

‡ "A purple scaly schist, which seems intermediate between micaceous and "argillaceous schist, and dips E. of S., is succeeded by an earthy and subschistose "gneiss * * * micaceous schist is then found, and resting on it a granitic gneiss "which is connected with the * * * granite."

CAPTAIN HERBERT, *Journal of the Asiatic Society*, XII. N.S. p. CIV.

Dwarra Hath with the metalliferous clay-slate of *Tilpoorà* on the south-east. In the neighbourhood of the principal mines, however, the series comprises—quartz-rock,—clay-slate,—quartzose-conglomerate,—and siliceous limestone. Overlying—at least a portion of the conglomerate at *Rampoore,* and immediately beneath the breccia subordinate to it at *Burralgaon,*—the iron-ore in other parts of the district occurs but little above the middle of the clay-slate formation. Exhibiting numerous and—in some instances—considerable inflections; the system generally dips E.—N.E. 20°—45°, and bears N. and S.,—S.E. and N.W.

Largely quarried as a building material, and for the construction of smelting-furnaces in the neighbourhood, the quartz-rock of Dhodulee and Simul-khet contains no foreign ingredient except the thin flakes of mica, —which disposed in corresponding—but somewhat distant planes,—impress on the mass a very thick-lamellar structure: this bears nearly N. and S.; whilst two systems of joints, which traverse the rock, *range*—one about 25° W. of N. and E. of S.,—the other 25° S. of E. and N. of W.

The lower portions of the clay-slate formation abound in felspar, are of a pearl-white, bluish-grey, or pale-blue colour, and rather thick-lamellar structure; on either side of the iron-formation, however, the rock partakes, at intervals, almost every shade of red and brown, and is traversed by many of the interlacing curvilinear joints, so numerous at *Dhunpoore**; quartz—sometimes mixed

* *Ante*, p. 13.

with a little calcareous matter,—meanwhile, appears towards its upper confines; greenish tints,—accompanied by a flinty fracture,—are occasionally exhibited, and it assumes, at length, the character of a breccia.

The siliceous breccia and green flinty slate pass gradually into a quartzose conglomerate, which appears beneath the iron-ore in the middle of the clay-slate at *Rampoore;* though in *Khetsaree*—the nearest mine—on the S.E., at *Simul-khet*—the next—on the N.W., and elsewhere through the district, it overlies both. Whether this unusual position be consequent on a deflection from its general *strike*, or on interruptions of its continuity, has not been ascertained; as on either side of *Rampoore* the ore remains unwrought, and the rock is covered with earth and vegetation.

The calcareous matter, more or less abundant throughout the quartzose conglomerate, is,—probably by the percolation of rain-water,—derived from the siliceous limestone formation; which—enclosing many masses of calcareous-spar,—but apparently destitute of organic remains,—extends westward no further than the range immediately east of Kotelar and Khetsaree, where it overlies the rest of the series: eastward, however, it reaches Kala Bun—north, and *Tarag-ke-Tal** south,—of the Ramgunga.

Generally parallel to the structure, and to some extent partaking the nature of the clay-slate, which—except at *Rampoore* and *Burrulgaon*—bounds it on either side,—the iron-formation encloses quantities of

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* *Ante*, p. 18.

slate and quartz; sometimes separate, sometimes mixed, but always transfused with ore. To such an extent indeed do the earthy ingredients occasionally prevail, that too refractory from the admixture, for the primitive smelting-furnaces of the natives, enormous masses remain unwrought. At intervals, however, portions, almost exclusively of pure ore, are largely worked; and these invariably dip or *shoot*, from the granite of Dwarra Hath, towards the north or north-west.* Red iron-ore, generally compact, but now and then of fibrous structure, is as well the characteristic as the most valuable part of the formation; whilst an earthy variety of the same mineral lines every crevice, and colours the adjoining rocks. Few metalliferous deposits vary in size so much as this varies in different parts of its course; for whilst at *Tilpoorà*, in the south-east, it is but two feet and a half in width, at *Simul-khet* on the north-west, it has been wrought for a breadth of more than six fathoms, without having reached either of its *(walls)* sides. The relative situations of the mines, and other essential details are given in *Table* II.

West of the principal deposit, at *Tilpoorà* and *Simul-khet*, other parallel though much smaller beds of the same ore have been wrought in clay-slate; but whether they are independent of, or subordinate to it, has not been ascertained.

At *Soongaree*,† a western tributary of the Khetsaree

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* Cornwall Geol. Trans. v. p. 193; vi. p. 146.

† *Extracts from the Records of Government* (Calcutta, 1855), p. 24.

about two miles from *Bonegarh*, several beds of a few inches, and one as much as a foot and a half, in width, all composed in great measure of quartz, but mixed, in the former with earthy-brown, in the latter with specular, iron-ore, bear 10° E. of N. and W. of S., and dip towards the west; as also do the laminæ of the brownish clay-slate adjoining them.

Traces of specular iron-ore also occur in massive quartz-rock beneath the slate of *Baroolee*,* immediately north-west of *Simul-khet*.

No connexion has been traced between the great iron-formation of Kotelar and Khetsaree, and the small quantities of red iron-ore dispersed,—sometimes in small detached compact lumps through the strata,—sometimes in an earthy form, between the laminæ and in the joints of greenish-brown, and occasionally greyish-white, fissile slate of Mehelchowree,† and diffused through quartz-rock on the top of Beansee,‡ a mountain still further to the north.

The district of Dhuniakóte,§ comprehending the *Khuloagarh*, *Hurchinolee*, *Tutyl*, *Oojowlee*, *Khurna*, *Kyroolee*, and *Patol*, iron-mines formerly wrought in the mountains on either—but especially on the south—

* *Extracts from the Records of Government* (Calcutta, 1855), p. 24.

† Captain Herbert, *Asiatic Researches*, I. p. 255; *Journal of the Asiatic Society*, XII. N.S. p. CIII.

‡ *Extracts from the Records of Government* (Calcutta, 1855), p. 25.

§ Captain Herbert, *Asiatic Researches*, I. p. 254. Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 300. *Extracts from the Records of Government* (Calcutta, 1855), p. 14.

side of the Kosila, is now—from the scarcity of fire-wood—almost abandoned.

Large tracts of homogeneous, dark-blue slate of silky lustre,—upper members, probably, of the clay-slate series,—are enclosed by, and intermixed with, quartz; which,—in other districts only occasionally present, is here,—sometimes interlaid by isolated slaty laminæ—often the chief ingredient. And, either diffused through, or alternating with, the slaty and quartzose rocks in short, thin, and irregular, though separate beds, calcareous matter abounds in the shallower—and is rarely wanting in any part of the system.

Either because the broken and impracticable surface has prevented sufficient search,—from still further changes in mineral character* than those presented in various parts of its range towards the south-east,—or from other less obvious causes, the great iron formation which crosses Ramgurh, has not been recognized in Dhuniakóte although the districts adjoin on the line of its course to the north-west; nor has any metalliferous deposit been identified in a second mine of the latter.

The ore most abundant in Dhuniakóte is red hematite;† but some mines have yielded earthy-brown and specular iron-ores also.

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* *Ante*, p. 24.

† Captain Herbert, *Asiatic Researches*, I. p. 254.

"The iron ores of Dhunneea Kote (chiefly red hematite) are found in numerous "localities * * * the mines might become very valuable in case railroads should "be formed in Northern India. As it is they are so neglected that, our Executive "Engineers sent to Calcutta for the iron of three suspension bridges erected in "their immediate neighbourhood."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 300.

(*j.*) A few low and ruinous *(levels)* galleries,—the heaps of glossy blue calcareous slaty rubbish broken in them,—and some scattered flakes of specular iron-ores they contain, are the only traces of ancient works now remaining at the mines in the neighbourhood, of *Khuloagarh* and *Hurchinoolee.**

(*k.*) The lowest in a series of small mines formerly wrought at *Tutyl*† affords specular iron-ore, alternating with beds of bluish-green calcareous slate, which bear 5°—10° E. of N. and W. of S., and dip 30°—40° W. The structure is, at times, thick lamellar, and then nodules of either substance are frequently enclosed in the other: ordinarily, however, the layers of ore are merely a fraction of an inch in thickness and but a few inches in length, and on such occasions they partake every flexure and contortion of the thin-bedded and fissile rock they interlie.

Parallel to the mottled blue, brown, and buff-coloured slate-rock above and below, the formation, worked in the second mine, is about four or five feet in width,—bears nearly E. and W.,—dips N. 30°—36°; and composed principally of compact brown iron-ore mixed with slaty matter, frequently contains also the carbonates of iron and lime.‡

Other researches were made in a third locality, but all traces of them have been obliterated by a land-slip.

(*l.*) The thick-lamellar quartz-rock, now and then tinged with slaty matter, which forms both banks of

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* *Extracts from the Records of Government* (Calcutta, 1855), p. 14.

† *Ibid*, p. 16. ‡ *Ibid*, p. 16.

the Khurna, is—near its union with the Kosila—interlaid by a bed of fibrous quartz some four or five fathoms in width, bearing about 15° S. of E. and N. of W., and dipping 35°—45° S. Often merely as a colouring matter,—more frequently mixed with quartz,—but at times the most abundant ingredient, and ever varying either in proportion or arrangement, red iron-ore,—either earthy, fibrous, or massive, is always present. The native smelter is however able to treat successfully only the richest and softest ores; in pursuit of these therefore the formation has been burrowed in all directions: but though much is still in sight, owing to the scarcity of fuel, the mine has been long abandoned.*

(*m.*) On the edge of a precipice rising perhaps three thousand feet above the river, *Oojowlee* † has been wrought in a bed of limestone, everywhere more or less siliceous, of which neither the direction, dip, nor width, has been ascertained. It is however traversed by joints which bear nearly S.E. and N.W., and—flattest in the most siliceous portions—dip 26°—70° N.E. Isolated lenticular masses, and short, narrow beds of iron-ore interlie the rock in lines coincident with those of its structure. Some of these consist of specular, others of compact, brown iron-ore; the two varieties are however more frequently mixed than separate, and magnetic iron-ore is also common amongst them.‡

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* A dove was hatching its eggs on a ledge of rock at the entrance, when I visited the mine.

† *Extracts from the Records of Government* (Calcutta, 1855), p. 14.

‡ A stag had made its lair amongst the grass and ferns overgrowing the abandoned works at *Oojowlee.*

(*n.*) A few masses of compact brown iron-ore mixed with the carbonate of iron are found amongst the calcareo-siliceous rubbish which has fallen on the works and covers the formation at *Kyroolee**; a mine formerly wrought in the steep side of a mountain, some fifteen hundred feet above the Kosila.

At *Patol*,† about one hundred and twenty feet higher than *Kyroolee* on the same mountain, some openings have been made on a bed of compact brown iron-ore much mixed with quartz, and abounding in drusy cavities lined with lime, which bears about S.E. and N.W., though occasionally horizontal it has in general a slight dip S.W.,—and is from 4 to 12 feet in thickness.

A few trees in the least accessible glens near *Khuloagarh* have escaped the general havoc which has stripped this neighbourhood of fire-wood. These still supply fuel, as *Kyroolee* and *Patol* furnish ore to the only furnace now worked by natives in the district.

Higher in the series than any other metalliferous deposit in Kumaon, the calcareous slates of Dhuniakóte are overlaid, towards the south, for several miles, by a succession of limestones and slates,‡ traversed by hornblendic rocks,§ altogether destitute of every ore.

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* *Extracts from the Records of Government* (Calcutta, 1855), p. 15.

† *Ibid*, p. 16.

‡ The exterior portion of the great mountain region * * * consists of a mass "of argillaceous schists, grits, and limestones, intersected by one or more lines "of igneous action."

Captain Strachey, *Quarterly Journal of the Geological Society*, vii. p. 297.

§ "An outburst of considerable extent, chiefly of an amygdaloidal form, is "associated with the formation of several small lakes. * * * Not far from these "is another small lake called Naini-tál.* * * In the immediate vicinity * * * "are dykes of a well-defined crystalline greenstone."—*Ibid*, p. 298.

No part of the Sub-Himalayan range surpasses in beauty the scenery of Nynee Tal, Bheem Tal, and other small lakes in this region.

Quarried for burning, although not quite free from silica, a bluish-grey limestone, the upper member of this formation, is overlaid by sandstone,* which,—slopes to the plain;—and—rarely of great extent,—is, in some places, but a few fathoms thick.

The ordinary ingredients are siliceous sand and argillaceous clay; but talc is often present also. The general hue is pale-buff or greenish-grey; occasionally, however, the prevailing tint is imparted by earthy red iron-ore.

Spheroidal or reniform stones of quartz and of compact red iron-ore,—at times as small as pease,—

* "The sandstone formation which bounds the mountain tract to the South "towards the plains, assumes many different aspects here as it does in Europe; "upon the whole the resemblance is sufficiently striking to allow of our identifying "it with the newer red or saliferous sandstone. It is either a hard red gravelly "clay distinctly stratified, or the same clay enclosing rounded stones, or a mi- "caceous sandstone, which in hardness varies from loose sand to a rock that will "strike fire. This type is again modified by the admission of rounded pieces "passing into sandstone conglomerate. * * * The sandstone is always micaceous "in a high degree; it is most commonly of the ordinary colour, but sometimes "it is found of a dark bluish-grey, in which case it seems to loose its appearance "of a schistose structure, and becomes amorphous, breaking equally in every "direction. This type is further remarkable for containing kernels of superior "hardness to the base, which itself is more compact, and I might say clayey, "than the ordinary sandstone. It also contains less mica. This grey type also "passes into the conglomerate structure. * * * At Bhumowree it is seen in the "river bed, dipping N.E., at an angle of about 30°; but it has here scarcely any "developement. * * * At the Chilkein defile * * * it forms very extensive "strata, chiefly of the red clay type. In the bed of the Cosillah, occasionally "rounded stones are contained imbedded. * * * At Dhikoolee, the conglom- "erate character is perfect, the basis being still the red clay, but sometimes "indurated to a high degree. * * * At Chookoom * * * we find a greenish "grey sandstone with mica dipping S.W."

Capt. Herbert *Journal of the Asiatic Society*, xii. N.S. pp. cxxxiii. cxxxiv

frequently as large as eggs,—but generally about the size of acorns or of grapes,—are sparingly scattered through the other ingredients; sometimes, however, they are so numerous that,—cemented only by the other constituents,—they form, as one or the other mineral prevails, either a quartzose or a ferruginous conglomerate. So closely indeed are some nodules of the ore packed, and so richly is the cement uniting them impregnated with it, that certain portions of the formation at *Jham** near Huldwanee, and at *Loha Bahbur*† not far from Kaleedoongee assume rather a vein-like character. Seldom however are both quartz and iron-ore plentiful in the same neighbourhood; nor are the conglomerated masses of either often very large.

Approximately parallel to the mountain-chain of which they form the southern or south-western slope, the beds of sandstone generally bear about S.E. and N.W., and dip S.W.; although for short distances, in some parts of their course, they take an E. and W., and in others a N. and S. direction. But whatever the inclination of the sandstone-beds, the parallel masses of ferruginous conglomerate they include at *Bejapoore*‡ near Bhamouree dip towards the N.

The unusually open joints are faced with clay in the earthy—and with red iron-ochre in the metalliferous—parts of this formation.

Whilst in the mountainous regions,—rich iron-ore occurs in large masses,—fuel is untaxed,—and the

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* *Extracts from the Records of Government* (Calcutta, 1855), p. 13.

† Ibid, pp. 12, 46. ‡ Ibid, pp. 12, 46.

climate is good throughout the year;—in the plain (*Bhabur*—or *Turaee*), on the contrary, small nodules of ore—though the same in quality—are thinly sprinkled through the rock,—the farmer of Government revenue levies a tax* on the wood-cutter, and the climate drives even natives to their hills for half the year.†

Although hitherto of but little avail, experiments, sanctioned by Government, are still in progress at *Jham*, *Bejapoore*, *Loha Bhabur* and *Dechowree*.‡

The slight traces of ancient mining, and the remains of but a single furnace, amid the still flourishing woods of the Bhabur, attest however the preference of native workmen for the more abundant ore, and the untaxed, though scarcer, fuel, of the higher and healthier districts.

(C.) Near Dol§ at the head of the Punaar valley, and

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* "*Table of Rates according to which Farmers of Jungle produce are authorized* "*to collect in Kumaon Bhabur*":—

"Per Cart load of	Wood—depending on quality	4—6 annas	(=6—9 pence)
„	Charcoal	4 „	(6 „)
„	Bamboos	6 „	(9 „)
„	Reeds	6 „	(9 „)
„	Limestone	6 „	(9 „)
„	Burnt lime	12 „	(18 „)"

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 216.

† "Everything which hath the breath of life instinctively deserts these woods from the beginning of April to October."— Bishop Heber, *Narrative of a Journey through the Upper Provinces of India* (Edit. 1849), i. p. 251.

"The cultivators actually come down to the fields after sun-rise and again "mount their hills at sun-set, the night air between May and October being "considered fatal. * * * It is found difficult to keep up a small police force "during the unhealthy months."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 191.

‡ *Extracts from the Records of Government* (Calcutta, 1855), pp. 12, 46.

§ "At Dhol * * * the rock is of an earthy composition, and quite soft,

again in both banks of the Sooal the talco-micaceous rocks are succeeded by fissile clay-slate of silky lustre, which,—containing occasionally a few white and greyish laminæ, and some beds entirely black,—is for the most part of a dark blue colour. The more lightly tinted portions are in great measure felspathic ; the darker are tinted by graphite; which is generally diffused through the other ingredients, but now and then it forms separate layers. Near the Sooal these graphitic beds bear nearly N.E. and S.W., and dip towards the S.E., perhaps 20°; at the surface they are frequently of red, rusty, or brownish hues; and are often so thoroughly disintegrated, that though—whilst in place—they still retain their schistose structure,—a touch crumbles them to powder. Attempts have been made at the expense of Government to supply the market with plumbago from this formation ; but thinly sprinkled with reniform masses— at times as small as walnuts, though often as large as eggs, and more rarely

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" though preserving the appearance of strata, and of laminar or schistose structure " * * * It is of various colours: black, red, yellow, grey, white, always bright " and well defined. The black is the most abundant, the white the least so. * * *

" The ridge on which Almorah is situate, rises into the peak of Kaleenath, " and in the ascent thereto * * * the talco-micaceous schist * * * is observed to " pass into the same kind of soft earthy black rock which was described at Dhol. " It was here that the graphite was discovered lying on the surface in lumps, " the fragments of kidney shaped nodules. The largest specimen obtained, " however, was an oblate spheroid perfectly rounded, having a diameter of about " three inches. The latter contained small veins of quartz. The aspect of this " graphite till scraped or abraded was dull; in the latter case it was metallic. " The composition was fine earthy."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. pp. cxxvi, cxxviii.

" Graphite occurs in the * * * neighbourhood of Almora, * * * both in an " impure form disseminated in the schist, and in small nodules apparently quite " pure.

Captain Strachey, *Quarterly Journal of the Geol. Soc.*, vii. (1851) p. 299.

even as cocoa-nuts,—composed usually of ore mixed with quartz, but frequently of either ingredient alone,—it yielded merely a few hundred weight of plumbago, and the untoward experiments were therefore soon abandoned.

(D.) Traced from rocks of like mineral character in the interior, by their *débris* in valleys opening to the plain,* and widest opposite their gorges† *(the Bhabur)*, a deposit of boulders, pebbles, gravel and sand,—maintaining an uniform level where it touches the hills—extends several miles towards the south.‡ Penetrated two hundred and twenty one feet in one place,—one hundred and fifty at another,—and smaller depths elsewhere,§ it is utterly disproportionate as well in disposition as in extent to the transporting powers of existing streams‖ at any period of the year, notwith-

* "The Dehra Doon which is the principal of these vallies * * * is from the "Jumna to the Ganges about forty five miles in length. Its breadth is variable, "being in some places scarcely ten, in others fifteen miles. The surface is "undulated, and has, in particular directions a strong declivity. Many banks or "steps occur, varying in height from one to thirty feet. These generally follow "the course of the streams. * * * The range of hills which bounds the Doon "to the southward * * * form an uninterrupted chain or line of water-heads, "on each side of which they are intersected by deep gorges now the beds of "torrents. Those which open to the Doon, are strewed with fragments of the "same kind as those which cover the valley itself; but those which open plain-"ward, contain no fragments but of the rocks in situ, which are of entirely "different character and not possible to be confounded."—Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. pp. xxxiv. xxxv. clviii.

† "The distance from the common boundary of plain and mountain land at "which gravel was found was greater in the beds of rivers, or on their banks than "on the intermediate ground."—*Ibid*, p. clviii.

‡ *Ibid*, pp. xxxiii. cxxxv.
Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 184.
Captain Strachey, *Quarterly Journal of the Geological Society*, vii. (1851) p. 298.

§ Captain Herbert, *Journal of Asiatic Society*, xii. n.s. p. cxxxv.

‖ "In all the river beds we see that there are accumulations of gravel and "boulder stones, all perfectly rounded, and consequently all of them such as have

standing those which are mere rivulets in dry weather, become floods during the rains. The surface consists in some parts of boulders and pebbles only; in others gravel and sand are mixed with the coarser ingredients, and amongst these, at times, a few stunted shrubs have taken root; considerable tracts, however, covered with soil, and, at intervals artificially irrigated by Government,*—are richly varied with forests, pastures and corn-fields.† Owing, probably, to different sizes and arrangements of the ingredients, all parts of the formation are not equally pervious to water; rivers, of like magnitude when issuing from the hills, are therefore seldom of the same length.‡ And thus whilst one may disappear after a course of but a few hundred yards on the shingle; another, of equal volume, may—continually dwindling—keep its way for four or five miles. Moreover the length of the same stream will

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"been subject to the action of water. * * * That these collections should ever "have been formed by such bodies of water as are found at present in their vicinity, "is altogether inadmissible. Their extent, the size of the fragments, the "distance from which they are derived, above all, their great depth, and the "height at which they are found above the present bed of the river, all forbid so "incredible a supposition."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. clvii.

* An extensive system of irrigation has been admirably carried out from the Gola near Huldwanee, By Mr. Commissioner Batten and Captain Ramsay his first assistant.

† "Under the base of the hills surface irrigation from the several streams that "issue therefrom, can be carried on to a certain distance on either side of them "by means of water-courses taken off at different levels, this distance or point "of non-irrigation being determined by the slope of the country, and the absorbing "or retaining qualities of the soil, and consequently by the place of disappearance "of water in the several rivers. Hence in the *Upper Bhabur* so long as agri- "cultural population can be found, extensive patches of fine cultivation will "always exist, but at wide intervals and with but a short prolongation to the "southward.—Mr. Commissioner Batten, *Official Reports on Kumaon,* p. 184.

‡ *Ibid*, p. 184.

also vary, as its size and force alter with the seasons After a longer or shorter course, however, every stream reaching the *(Bhabur)* plain at length disappears; a certain breadth of it is therefore always destitute of water.*

From its surface dipping more rapidly than that of the rock beneath,—this formation—thickest where it is bounded by hills on the north,—thins gradually, throughout its breadth of ten or fifteen miles on the south, to an edge in the plains.

Arrested whilst descending by a floor of clay below the boulders, all streams engulphed near the hills, after a subterranean course of several miles along this impervious bed, reappear south of the shingle, and form, in the *Turaee*, a series of pestilent swamps.†

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* "The drainage of the lower mountains * * * flows at an hitherto undiscover-"able depth * * * beneath shallow mould and enormous gravel beds."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 184.

"All the minor streams as they leave the foot of the hills are rapidly absorbed "and disappear in the sandy and shingly deposits that there prevail, and wells "have to be sunk to a great depth before water can be met with."

Captain Strachey, *Quarterly Journal of the Geological Society*, vii. p. 296.

† "Along the foot of the mountains extends a tract called Bhabur * * * "distinguished by an almost total absence of springs or running streams. "* * * It is bounded to the southward by a line of springs or water-heads, which "is also the northern boundary of the tract called Terrai. * * * This track is "remarkable for its moisture as the other is for its dryness."

Captain Herbert, *Journal of the Asiatic Society*, xii. n.s. xxxix.

"Beneath the shallow mould and enormous gravel beds of the *ookhur bhoomee*, "or *dry* region of forest and grass, at an hitherto undiscoverable depth flows the "drainage of the lower mountains; the point of reappearance of water in the "river beds, and the rushing out of the multitudinous springs being determined "by the thinning out of the porous gravelly *detritus* and the approach of the clay "or *impervious stratum* to the surface. The *Lower Bhabur*, or special *Turaee* "succeeds. If left to itself, this region must become one of swamps and malaria; "and only partial cultivation. * * * The rapid slope of the country causes the "streams to push along the superficial gravel, mixed with trees and vegetable "mould, and thus to form at last an obstruction ahead of themselves. This

Whilst the heat and rain of summer continue, the very *Bhabur,* is so intolerable, that the native farmers retire with their cattle to the hills; and return to it, even at harvest, in day-time only.*

A bed of pebbles and gravel occurs about forty feet above the present bed of a southern tributary of the Ramgunga near Dwarra Hath; and similar deposits, though of coarser ingredients, some fifty feet from the river near Nehal-bridge † between Nynee Tal and Kaleedoongee, and at least two hundred and fifty feet higher than the Gola at Bhamouree; the first nearly three thousand five hundred, the two last perhaps three hundred feet above the Bhabur.‡ Although at

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"causes * * * at every corner a back-water * * * which irregularly floods all "the adjacent lands, and creates grass, *koonduls,* and swamps for tigers, deer, "and hogs, whilst it drives out the human inhabitant."

Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 185.

"The dry land of country is, I presume, a great talus of coarser matter that "has been formed along a former line of coast, covering a deposit of finer and "less permeable silt, just as appears to be usual now: the surface of the former "being naturally more inclined, of the latter almost horizontal, and the drainage "of the whole of the upper portion being brought to the surface along the line of "union of the two."

Captain Strachey, *Quarterly Journal of the Geological Society*, vii. p. 296.

By command of Government these interesting phenomena have been admirably illustrated in a "*Map of the Kotah and Chukkata Bhabur or Terae Forest af Zillah* " *Kumaon, surveyed under the superintendence of Lieutenants Vanrenen & Burgess.* " 1851-53."

Ice forms round the bamboos and other shrubs amongst the swamps in winter; but the temperature is often above 100° in the shade, during summer.

Elephants, tigers, leopards, hogs, hyænas, deer of many kinds, and pythons of enormous size, abound in the jungles.

* Bishop Heber's *Narrative of a Journey through the Upper Provinces of India* (Edit. 1849), i. p. 251. Captain Herbert, *Journal of the Asiatic Society,* xii. n.s. p. xxxvii. Mr. Commissioner Batten, *Official Reports on Kumaon,* 191. *Extracts from the Records of Government* (Calcutta, 1855), p. 14.

† Not many years since the river's ancient bed in this part of the valley was covered at once with earth and stones, to a depth of fifty feet, by a land-slip.

‡ Captain Herbert, *Journal of the Asiatic Society,* xii. n.s. pp. xx. clvii.

elevations so much greater than that of the enormous mass of shingle in the plains; these beds resemble it as well in the mineral character as in the form of their ingredients; probably therefore they may all be traced to a common origin and owe their shapes to the same agency: but whether—leaving no traces of passage on the mountain sides between them—they have been contemporaneously lodged in their present positions,—however interesting as a speculative question,—is be-beyond the scope of this enquiry.

(E.) Although there are points of resemblance between certain rocks in Kumaon and Gurhwal, and the auriferous formations of other Countries* ; no gold has yet been found *in sitû* amongst them. Towards the end of every rainy season, however, small quantities are found, amongst siliceous sand and shingle in the Ramgunga,† and mixed with fragments of garnet and granitic gravel in the Aluknunda,‡ and the Pindur. In no other part of the world, perhaps, would particles of gold so minute and so thinly scattered be worth extraction; here however, labour is so abundant and so cheap, that many poor families — though possessing but little skill and using only the rudest contrivances§ — subsist on the proceeds of their toil.

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* *Ante*, p. 29. *Note.*§

† "The gold of the Ramgunga * * * is traced to a tributary stream called "the Bení Gangá, which has its rise in the lower mountains, as it is only below "the confluence of the two that the sands are found productive."

Captain Herbert, *Asiatic Researches*, i. (1829) p. 236.

‡ "I obtained at *Kedarnath* one of the sources of the Aluknunda a specimen "of granite in which occurs a speck of gold."—*Ibid*, p. 236.

§ "The gravel in which the gold dust is always found * * * is collected in "heaps, and washed on a stage, or imperfect riddle, made of bamboos. The

And so thorough is the separation that a few grains of metal only were obtained, by a Cornish miner of great experience in the auriferous districts of California and Brazil, from rewashing large quantities of gravel previously treated by the natives.*

The whole quantity of gold collected in Kumaon and Gurhwal is so small, that the Royalty—levied during the Goorkha rule—is now scarcely an item of public revenue.†

The Bhotea traders whose flocks of sheep, goats, and *yaks* traverse the Himalayan passes laden ‡ with saltpetre and borax from Thibet; carry on also a small

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" pebbles of any size are retained by this, and then rejected; while the sand " which passes through the interstices, is carefully preserved. When a sufficient " quantity is collected, it is put into a wooden trough, of about three, to five, " feet in length, and a foot broad: being filled with water, the whole is agitated " by the hand, and such a degree of inclination skilfully given, as shall carry off " the lighter particles; leaving a heavy black sand, behind. It is in this sand, " that the particles of gold are found. It is triturated with quicksilver, which " takes up the gold; and the amalgam being separated from the still remaining " impurities, is set over a fire to evaporate the mercury: the gold remaining " behind in the vessel."

CAPTAIN HERBERT, *Asiatic Researches*, I. (1829), p. 238.

* *Extracts from the Records of Government* (Calcutta, 1855), pp. 3, 4.

† " The *gold* obtained from the sand of rivers; paid during the Gorkhalí rule, " a small duty; but the amount was too small to render its continuance expedient; " and it was accordingly abolished by the Commissioner."

CAPTAIN HERBERT, *Asiatic Researches*, I. (1829), p. 237.

" The gold washers who resort to the Ramgunga in the Patlee Dhoon earn " but a scanty subsistence, and the farmer * * * only pays Government 25 rs." " (about two pounds and ten shillings) " per annum for the privilege of collecting " the dues from these people."

MR. COMMISSIONER BATTEN, *Official Reports on Kumaon*, p. 157, Note.

‡ " The sheep carries a burthen of from five to eight seers " (10 to 16 lbs.), " and the goat from six to twelve seers " (12 to 24 lbs.). " Grain, borax, salt and " such articles are sewn up in small saddle bags, made of worsted, and cased with " leather; these are laid across the back, and are secured merely by a crupper " and breast band. * * * Laden sheep, on short journeys, can accomplish " seven or eight miles a day; but for a continuance, cannot keep up a greater " rate than five miles; they travel only for a short time in the morning and in " the evening, during the heat of the day they are unloaded and suffered to " graze."—MR. COMMISSIONER TRAILL, *Asiatic Researches; & Official Reports on Kumaon*, p. 78.

traffic in gold of great purity collected from sands of the *sacred lakes.**

The methods of mining and smelting which, adapted to local circumstances, were actively carried on whilst Kumaon and Gurhwal were subject to Goorkha rule, are still practised by the natives; and have been little, if at all, improved since the Country has fallen under British Government; as the smelter's means enable him to reduce none but the most fusible ores; such only are objects and guides to the miner. These are however for the most part irregularly mixed, commonly in isolated lumps and granules, but at times in short narrow veins, either with siliceous and other earthy ingredients, or more refractory ores.

Following, without system, every irregular disposition of the softest ore; the works seldom maintain for more than a few feet at a time either the same horizon, direction, or dimensions, but take upward and downward;—to the right hand and to the left;—divide and reunite;— enlarge to several feet and dwindle to as many inches, as well in width as in height, and all within a few fathoms space.†

The refractory is partially separated from the fusible ore at once; the former is carelessly stowed round the sides of the mine, the latter is removed for use.

* Mr. Commissioner Traill, *Asiatic Researches; & Official Reports on Kumaon*, p. 101. Lloyd & Gerard, *Journey from Caunpoore to the Boorendo pass*, p. 232. *Encyclopædia Metropolitana* (Thibet), xxv. p. 589. *Penny Cyclo.* (Himalaya), xii. p. 198.

† "The mines resemble, as Mr. Traill has observed, rather the burrow of an "animal, than the path of a human being."

Captain Herbert, *Asiatic Researches*, i. (1829), p. 240.

Extracts from the Records of Government (Calcutta 1855), pp. 28, 30, 33.

Through passages so narrow, low, and crooked, and over floors so uneven as these, it is, however, impossible to convey it to the surface, either in wheel-barrows and tram-waggons worked by hand, as in Europe;—in *Carrumbès** borne on the head, as in Brazil;—or in leathern sacks on the shoulders, as in Chili.† It is therefore either packed in small bags, or heaped on strips, of hide; one end of a cord is tied to this load, and the other is passed round the loins of a workman; who, creeping and wriggling through the narrow passages, thus drags it after him to the surface.‡ Nor is this irksome toil without danger; for the ill-propped rubbish on each side set in motion,—in rare instances by earthquakes,§ but more commonly either by a touch from the unwieldy load behind him or by his own struggles in drawing it,—has sometimes closed on the unhappy labourer. In such cases the natives prefer opening new mines on the same formation, to resuming the old ones.||

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* "Flat wooden bowls, about a foot and a half in diameter."
GARDNER, *Travels in the Interior of Brazil*, p. 450.

† Captain Basil Hall, *Journal written on the coast of Chili, Peru, and Mexico*, II. p. 32. Sir F. Bond Head, Bart. (Edit. 1826), *Journey across the Pampas*, p. 225. *Darwin*, *Journal of Researches in the Native History and Geology of the Countries visited by H. M. S. Beagle* (Second Edition), p. 341.

‡ "The ore is brought out of the mine on buffaloe hides, which are dragged "along the ground by boys, with a rope tied to one end, and passed round their "bodies."—MR. COMMISSIONER TRAILL, *Asiatic Researches*, XVI. p. 137.

Extracts from the Records of Government (Calcutta, 1855), p. 28.

§ "Kemaoon is extremely subject to earthquakes; scarcely a year passes "without a shake or two."—BISHOP HEBER, *Narative of a Journey through the upper provinces of India* (Edit. 1849), I. p. 272.

Mr. Commissioner Traill, *Asiatic Researches*, XVI. p. 137.

At Almora the shocks of earthquakes are felt much more severely on the sides than along the ridge of the mountain.

|| Mr. Commissioner Traill, *Asiatic Researches*, XVI. p. 137.

As these ragged holes are unfit equally for channels and for roads, the miners are sometimes incommoded although their works are seldom or never flooded, for they are generally at such elevations that water entering them again oozes out through natural crevices and joints. *Mungla Lekh* is therefore the only iron-mine in these Provinces whence water flows to the surface through *(an adit)* a gallery.*

As the copper deposits offer from their less porous structure—fewer channels for the passage of water than are natural to the iron series; the galleries *(adits)* by which their drainage is accomplished were originally made with proportionally greater care. Commenced whilst the Country was subject to Goorkha rule, their outer portions,—though of smaller dimentions than are usual in Europe,—are large enough for ordinary purposes, and were at first carefully timbered. Since it has fallen under British dominion however the Royalties have been formed by native middle-men; who not only exact heavy rents from the miners, but limit their tenures to one year. Terms such as these are, of course, declined by capitalists; the labourers therefore become themselves tenants. As the government neither exercises supervision nor affords them protection, and they are prevented both by their poverty and by the restrictions of their leases from pursuit of objects unattainable within the year, they confine themselves to maintaining the drainage as cheaply as possible and to works immediately productive.

* *Extracts from the Records of Government* (Calcutta, 1855), p. 20.

The small and ill-made mining tools,* entirely of iron,—are picks, hammers, wedges *(gads)*, and pointed bars, perhaps half the weight, and scarcely one-third the efficiency of those used for similar work in other Countries. With these however the miners at *Burral-gaon* extract from (two to six *maunds)* 160 to 480 lbs. and in other districts about (six *maunds)* 480 lbs.† of iron-ore per day each.‡ But they are unequal either to breaking or to boring the siliceous formations; nor indeed have the native labourers opportunities of obtaining gunpowder. As therefore means of blasting are not attainable, the harder rocks are partially calcined *in*

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* Mr. Commissioner Traill, *Asiatic Researches*, XVI. (1828), p. 137. Captain Herbert, *Ibid*, I. (1829), p. 244. Captain (now Lieut. Col.) Drummond, *Journal of the Asiatic Society*, VII. (1838), p. 936. *Extracts from the Records of Government* (Calcutta, 1835), p. 27.

† At *Simul-khet* Mr. Deputy Collector Becket found each miner breaking from (eight to twelve *maunds)* 640 to 960 lbs. of ore per day: but this much above an average. *Selections from the Records of Government, N.W.P.*, Part XIII. (1853), p. 69.

‡ *Extracts from the Records of Government*, (Calcutta, 1855), p. 29.

§ "The ores are the softest part of the rock, and are consequently dug out "first, after which the miners burn the rock with wood and then throw water on "it. Owing to the calcareous nature of the rock, this process facilitates the work "considerably; but still I think blasting would be cheaper, as the burning does "not penetrate beyond a few inches in the rock."

MR. COMMISSIONER LUSHINGTON, *Journal of the Asiatic Society*, XII. N.S. p. 464.

At *Fahlun* in Sweden "fires are kindled in different parts of the mine every "*Saturday* about noon; which continue burning the whole of *Saturday* night, "and all *Sunday*, with a view to soften the rocks, and facilitate their being "wrought for the ore. Gunpowder was formerly used for blasting; but this is "now applied sparingly: it being the opinion of the most experienced men in "*Fahlun*, that a judicious application of the two methods succeeds better than "either of them alone; for, as the blasting by gunpowder always leaves a certain "number of irregular projections in the rocks, the subsequent process of applying "fire to these inequalities tends to soften them, and to expedite the fall of the "ore. The fires * * * are under the strictest regulations: the exact quantity of "wood that shall be consumed is duly specified, and moreover, the precise portion "of the rocks to which the several fires are to be applied." *Travels in various countries of Europe, Asia, and Africa.* By EDWARD DANIEL CLARKE, L.L.D. (Edit. 1824), X. p. 531.

sitû,§ and, thus softened, are wrought with the ordinary mining utensils. But though, from imperfect ventilation, the fires kindled in mines, soon expire; the foul air and smoke they diffuse, materially incommode the workmen and impede their operations.

Torches of pine-wood are used by the miners when at work,* and serve their purposes very well; but they vitiate the air more than either oil or candles giving equal light.

Under the superintendence of Mr. Wilkin a Cornishman, an attempt was made by Government in 1838-41 to examine the mineral resources,—especially the copper formations,—of this district; and to introduce at the same time better tools, and improved modes of mining, amongst the natives. The experiment was conducted at *Pokree*,† a lone spot midway between the *Dhunpoore* ‡ copper-mine and the snowy range, near the northern confines of British India. The metalliferous deposits examined offered no especial allurements at the surface, and their appearances did not improve as they were followed downward.§ The works

* "Strips of turpentine fir, are used for light."—Mr. Commissioner Traill, *Asiatic Researches*, xvi. p. 138.

At *Röraas* in Norway "the guides who accompanied us, carried with them deal "splinters, bound into faggots, each bundle being about as thick as a man's arm, "These splinters they use as torches." *Travels in various countries of Europe, Asia, and Africa*. By Edward Daniel Clarke, L.L.D. (Edit. 1824), x. p. 187.

† *Ante*, p. 6. ‡ *Ibid*, p. 11.

§ Mr. Wilkin's experiment extended over a period of two years and eight months; and the galleries, shafts, and *winzes* opened measured 257½ fathoms;

the copper-ore obtained realized	779½ rupees, or		£77	19	0;
and the amount expended, for native labour and materials was..	3364½ ,,	£336 9 0			
and for European superintendence..	4800 ,,	480 0 0			
	8164½ rupees, or		816	9	0.
A loss was therefore incurred on it of	7385 rupees, or		£738	10	0.

instituted on them were, however, ably designed, well opened,* skilfully timbered, and carefully drained; barrows were used in the galleries *(levels)*, and windlasses† *(takles)* and buckets *(kibbles)* in the shafts and *winzes;*‡ whilst inhabitants of the neighbourhood were taught the advantages of systematic mining,—to make and use tools common in Europe,—and to improve the implements already employed and wield them with greater effect. The benefit of this instruction, though still enjoyed at *Pokree*, has not yet extended to other districts.

When brought to the surface iron-ore is broken into pieces about the size of chestnuts, and washed by women and children; the less fusible varieties are rejected, and—except at *Pahlee* § and *Sahloo* ‖ where it is first calcined,—the rest is ready for the furnace.¶

Enormous quantities of rich ore, which would have been eagerly sought in any other country, are too refractory for the native smelter's small furnaces and feeble blast; and thus,—worthless to him,—cumber the passages and surface of every mine in the Provinces.**

Mr. Commissioner Lushington, *Journal of the Asiatic Society*, XII. N.S. pp. 457, 458, 467. *Official Reports on Kumaon*, pp. 370, 371, 379.

* "One or two barrels of gunpowder were expended in blasting."—MR. COMMISSIONER LUSHINGTON, *Journal of the Asiatic Society*, XII. N.S. p. 456. Note.

† A straw-rope was worked with the windlass and bucket at *Khetsaree*.

‡ "*Winze*,—an opening on the dip of a vein from one gallery to another, "which does not reach the surface."—*Cornwall Geol. Trans*, v. p. 6.

§ *Ante*, p. 25. ‖ *Ante*, p. 19.

¶ *Extracts from the Records of Government* (Calcutta, 1855), p. 29.

** *Ibid*, pp. 29. 30.

Every group of mines affords stone suitable for furnaces, and they are generally made about two or two and a half feet high, and from twenty inches to two feet in diameter within. The blast is maintained in them by the alternate action of two air-bags * (for without frame-work they can scarcely be called bellows), made of buffalo-skins, and hand-worked by women, without even a brake-staff.

Iron ores are in many mines † naturally associated with lime enough to satisfy every chemical requirement of the smelter. The advantages obtained by mixing specular-iron from *Nutoa Kanh* ‡ with compact brown iron-ore of neighbouring mines § have not however taught the natives to use fluxes elsewhere.||

The ordinary charge,—from four to five hundred lbs. of ore with the requisite fuel,—not only fills the furnace, but forms also a conical head, of perhaps a foot, above it; but the heat obtained is neither sufficiently great, nor long enough maintained, either to reduce the whole charge, or to free the liquified portion of it from slag, in a single process; the mass partially smelted in one furnace is therefore further refined in another. The metal thus obtained is repeatedly heated, welded, and hammered, and is then fit for use.¶ Its

* "The heat is urged by two air-bags or skins, which are alternately shut and "opened by the hand."—Capt. Herbert, *Asiatic Researches*, I. (1829), p. 244.

† *Ante*, pp. 31, 35, 37. *Table II.* ‡ *Ante*, p. 23. *Table I.*

§ *Ante*, p. 22. *Table I.*

|| Captain Herbert, *Asiatic Researches*, I. (1829), p. 252.

¶ "The ore is, in the first instance, broken small, and roasted by the miners, "until the whole quantity adheres together, forming a single mass: in this state "it is delivered by them, for further process, to the blacksmiths, by whom the

quality is generally very good; but trifling peculiarities mark the produce of different localities. Steel made at Sheffield * from iron smelted at *Purturburá;* † closely resembled that obtained by converting Swedish iron of second quality.

From one-fifth to one-third of the ore remains, from every charge, unsmelted in the furnace.‡

Although oaks flourish near some of the mines; and hard-wood,—whether charred or uncharred,—makes a stronger and more enduring fire than soft; whilst large pieces, of any quality, afford greater heat than small ones: fir-charcoal,—seldom more than three inches in diameter and generally much less,§—is,—because it is obtained with least labour,—the only fuel used for smelting; and want of due care in preparing this materially diminishes its value. The destruction of saplings by the charcoal-burners is not remedied by a succession of younger trees; for all such either perish

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" roasted ore is once more broken small, and then exposed in crucibles to a strong " heat, sufficient to fuse the vitreous matter, which runs off through a hole left " for that purpose. The metal remains in the crucible, and is then beaten up " into small bars for the market."

MR. COMMISSIONER TRAILL, *Asiatic Researches*, XVI. p. 138.

" The iron is never smelted, but comes out of the furnace in porous knobs very " much the size and shape of the original pieces of ore. * * * The miner is " content with selling them in this state to the blacksmiths who, again, are very " sparing in labour when shaping them into the pigs in which they are finally " sold in the bazar."—CAPTAIN HERBERT, *Asiatic Researches*, L. (1829), p. 252.

* By Messrs. Johnson, at the " Western Works."

† *Ante*, p. 24. *Table I.*

‡ This residue is equally shared, between the farmer of Government dues and the smelter.

§ *Extracts from the Records of Government* (Calcutta, 1855), p. 31.

or are greatly injured when the surrounding herbage,—having withered during winter,—is burnt, as spring approaches, that its ashes may nourish the growing grass. When smaller wood is no longer obtainable the largest pines are felled; and, as it is easier to lop their branches than to split their trunks, the former are charred, whilst the latter are left to rot where they fall.* This reckless waste of so much valuable timber has long been a subject as well of public remark† as of official remonstrance,‡ but Government has taken no measures either to arrest it, or to maintain the forests.

Alternately, either farmers, or miners and smelters, the workmen leave the field for the mine and furnace, or return to it, as the season may be suitable for labour in either;§ but as the climate is not uniform, their migrations are not contemporaneous, throughout the Provinces. As mining and smelting are carried on by parties too poor either to sell on credit, or to be trusted by the middle-man for his dues; their transactions—

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* "In the valley of Khetsaree * * * the extensive pine woods of the Door-"gadhee and Jowrasee range, even at the distance of five or six miles from the "mines, are now beginning to experience indiscriminate havoc at the hands of "the charcoal burners, who cut down and leave to rot on the ground thousands "of fine trees, merely consuming the smaller branches, (to save themselves the "trouble of splitting the large trunks), while no provision is made for the renewal "of the forest."—Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 469.

† Bishop Heber, *Narrative of a Journey through the Upper Provinces of India*, (Edit. 1849), i. p. 274.

‡ Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 469. Mr. Deputy Collector Beckett, *Selections from the Records of Government*, N.W.P. (1853), pp. 71–5. *Extracts from the Records of Government* (Calcutta, 1855), pp. 32–6.

§ Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 303. *Ante*, p. 21. *Extracts from the Records of Government* (Calcutta, 1855), pp. 14, 20.

always closed immediately—need no record. And, as all Royalties are now farmed, Government is,—for the present at least,—but indirectly interested in the returns from its mineral property: the capabilities of the mines, the produce of the furnaces, the state of the forests, and the number and condition of the people employed in them are therefore unknown.

During the spring of 1855 there were worked in Kumaon and Gurhwal*:

Districts.	Iron Furnaces. Smelting.	Refining.	Total.
Kotelar and Khetsaree †	16	22	38
Chowgurhka, &c. ‡	28	39	67
Agur §	7	8	15
Dhuniakóte ‖	1	—	1
Bhabur ¶	—	—	—
	52	69	121

In the processes witnessed by Mr. Deputy Collector Beckett** at *Simulkhet*, 1,860 lbs. of compact and hematitic red iron-ore were smelted with 680 lbs. of charcoal and yielded 655 lbs. of *bloom*, which refined with 654 lbs. of charcoal afforded 163½ lbs. of bar-iron.

264 lbs. of similar ores from the same formation reduced with 192 lbs. of charcoal by native smelters

* *Extracts from the Records of Government* (Calcutta, 1855), p. 43.

† *Ante*, p. 29. ‡ *Ante*, p. 18. § *Ante*, p. 21.

‖ *Ante*, p. 33. ¶ *Ante*, p.38.

** *Selections from the Records of Government*, N.W.P., Part XIII. (1853), p. 67. *Extracts from the Records of Government* (Calcutta, 1855), p. 39.

at *Burrulgaon* in presence of Mr. Davies, my Metallurgic Assistant, produced 80 lbs. of *bloom;* and this treated with 84 lbs. of charcoal gave 24 lbs. of saleable metal.*

The following columns show the proportions of *bloom* and bar-iron obtained from like quantities of ore; and the relative amounts of fuel used for smelting and refining, in the two operations.

	Smelting.			Refining.			
Mine.	*Ore.*		*Charcoal.*		*Bloom.*		*Charcoal.*		*Bar-iron.*
	lbs.		lbs.		lbs.		lbs.		lbs.
Simul-khet ..	100	....	36·55	=	35·21	....	35·16	=	8.79
Burrulgaon..	100	....	72·72	=	30·3	....	31·81	=	9·09

These ores contain when pure, more than sixty per cent of metal†; but the most scrupulously selected portions of them, carefully freed from impurities, yield to the native smelter less than one-tenth of their weight in bar-iron.

Each party working underground usually consists of two miners *(Soanes)* and four labourers *(Coolies):* the former open and timber the works; the latter stow all poor ore in unwrought holes, and draw that of better quality to the surface; where,—exercising a second scrutiny,—they reject every refractory ingredient, but carry all fusible matter to the furnace. Each miner's complement of tools costs about (eight *annas)* one

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* *Extracts from the Records of Government* (Calcutta, 1855), p. 39.

† *Memoirs of the Geological Survey of Great Britain.* Iron-ores. *Part I.* (1856), pp. 60-66.

shilling per month for repair, and consists of two picks, two hammers, several wedges *(gads)*, and, occasionally a pointed bar, all made of iron; the labourers use only hammers, and strips or bags of hide. A few brief intervals, devoted to the celebration of Pagan rites, alone vary the native workman's constant toil of eight hours daily throughout the year:* the month may therefore average twenty eight working days. More than half the ore broken needs for its reduction a heat far greater than any native furnace ever attains: useless, therefore, to the smelter, all such is either left underground, or rejected when brought to the surface. The available portion,—varying with circumstances,—averages perhaps about (five *maunds)* 400 lbs. per day for each of the two miners in every working party.†

When ready for smelting the ore is divided into five equal portions; of which

the Farmer of Government Royalties . . . takes one;
,, Smelter . . . . ,, one;
,, Charcoal burners . . . . ,, two;
,, Miner and his two labourers *(coolies)* ,, one.

But the miner has still to share his part with his two labourers *(coolies)*; who halve one moiety of it between them, whilst he takes the other. Even this suffers further reduction; for about a quarter of every charge remains unfused in the furnace and is equally divided between the Farmer of Government Royalties and the Smelter.

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* *Extracts from the Records of Government* (Calcutta, 1835), p. 29.

† *Ibid*, pp. 29, 30.

During the miner's working month of twenty eight days, he obtains on an average, 400 lbs. of cleaned ore daily; in which his share—a moiety of one-fifth—is 1,120 lbs.; and this—at nine per cent:—the general yield of native furnaces in Kotelar and Khetsaree—affords about 100 lbs. of metal. The ordinary price of home-smelted bar-iron in Kumaon and Gurhwal is ten rupees for fifty six *seers*, or one Pound sterling per hundred-weight; at which rate the miner's gross income amounts to about (nine rupees) eighteen shillings per month. But the ordinary working party, of two *(Soanes)* miners and four *(Coolies)* labourers, whilst smelting their portion of the ore,—which they do without sub-dividing it,—provide the smelter and his assistants with 20 lbs.* of meal daily; this costs—even in the cheapest districts,† at least (one rupee) two shillings per month to each *(Soane)* miner for his one-fourth part. This with another (eight *annas)* shilling for repair of tools, deducted from the value of his iron, reduces the miner's net earnings to about (seven rupees and a half) fifteen shillings per month, or barely sixpence half-penny a day. The miner's skill, the nature of his ore, and the price of iron, all—of course—affect, more or less, the amount of his gettings; but,—though sometimes as low as five pence;—they seldom exceed seven pence per day‡.

* The chief Smelter takes 4 lbs., his sledge-man and four women who work the (air-bags) bellows each 3 1-5th lbs.

† "In the western midland pergunnahs of Gerhwal * * * wheat is selling "at two maunds (160 lbs.) the rupee."—Mr. Commissioner Traill, *Asiatic Researches*, xvii. *Official Reports on Kumaon*, p. 98.

‡ *Extracts from the Records of Government* (Calcutta, 1855), p. 30.

Entitled to but half as much ore,—supplying the smelter with only half as much meal,—as the miner,—and providing no tools, the labourer's usual earnings are about (four rupees and a half) nine shillings a month or scarcely four pence per day: occasionally, however, he may assist either the miner or the smelter, and thus obtain,—at most—another penny.

The wages of ordinary labourers is still smaller.*

As the miner and his two labourers realize, between them, about (eighteen rupees) thirty six shillings per month, by selling the iron (200 lbs.) obtained from their shares in the 11,200 lbs. of ore they break *(dress)*, prepare, and carry to the furnace; every (21 cwts.) ton of such ore delivered at the smelting-house stands them in about seven shillings and seven pence. More than half the ore extracted is, however, too refractory for native treatment, although comparatively little of it is beyond the skill of European smelters; ordinary blast-furnaces might therefore be supplied with ore, of but slightly inferior quality to that now selected for use, at from three shillings to three shillings and six-pence per ton.†

Throughout Kumaon and Gurhwal the estimated

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* "Two annas" (three-pence) "per diem is the usual rate of hire, but to en-"sure a constant supply of labour it would probably be found necessary to raise "it to 3 or 4 annas."—Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 470.

Extracts from the Records of Government (Calcutta, 1855), p. 30.

"Even the modest sum of (sixty-six rupees) Six Pounds and twelve shillings "exceeds the annual gains of the common Hindoo labourer."

The Times, 24th October, 1859.

† *Extracts from the Records of Government* (Calcutta, 1835), p. 30.

price of charcoal delivered at the furnace from forests within four miles, is about (three *annas)* four pence half-penny for (30 *seers)* 60 lbs.,* or fourteen shillings and eight pence per ton.†

The Mining Royalties collected in these Provinces by the Goorkha Government during 1812, were—from

Kumaon,	2,400	*Furruckabad*	rupees, or	1,800	*Company's*	rupees.
Gurhwal,	2,401	„	„	1,800¾	„	„
	4,801‡	„	„	3,600¾§	„	„

British dominion was established during 1815; and the revenue—in one year as low as 4,460 ‖ rupees, and in another as high as 5,417,¶—averaged from that period to 1838 about 5,217 rupees; viz.,—from

	Copper.	*Iron.*	*Total.*
Kumaon	1,000	1,905	2,905
Gurhwal	2,086	226	2,312
	3,086	2,131	5,217 **

* *Extracts from the Records of Government* (Calcutta, 1835), p. 33.

† Information was obtained from many parties relative to the division of their ore, and the amounts of their earnings; but from no one so thoroughly conversant with every particular of native mining economy as *Kishna Pudhan* of Parturá (Collector of Revenue. *Official Reports on Kumaon*, p. 464), who farmed the Government Royalty of iron mines during 1854-5.

‡ Mr. Commissioner Traill, *Official Reports on Kumaon. Appendix. Statement B.*

§ Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 457, *Note. Official Reports on Kumaon*, p. 369, *Note.*

‖ In 1822–3 the Cess on Copper mines was .... 3,360 rupees.
„ „ Iron „ .... 1,100 „
Mr. Com. Traill, *Asiatic Researches*, xvi. *Official Reports on Kumaon*, p. 51.

¶ Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii., n.s., p. 457, *Note. Official Reports on Kumaon*, p. 369, *Note.*

** *Ibid.*

In 1855 the amount of Royalty had materially declined: for all works at *Rai,** *Bellăr,*† *Goron,*† and *Tarag-ke-Tal*‡ having been abandoned; whilst *Dhunpoore,* §*Pokree*‖, *Al Agur,*† *Kurrye,*¶ and *Seera*** were languidly, and inefficiently wrought; the public income from copper-mines fell, during that year, short of........................ 1,900 rupees.

The farmer of Government dues from iron-mines paid, at the same time, a rent of .... 1,950 „

Although therefore the mining revenue had increased from about three hundred and sixty before,—to above five hundred Pounds a year after—the British conquest, it has again dwindled, to little more than its previous amount.

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* "At present the revenue derived from these mines is only 101 rupees per "annum.—Mr. Commissioner Batten, *Official Reports on Kumaon*, p. 274.

† Neither of these mines is mentioned in any *Official Report on Kumaon.*

‡ "There is a small copper-mine recently opened,— jumma" (annual rent) "35 rupees."—Mr. Com. Batten, *Official Reports on Kumaon*, p. 317, Note.

§ "Twenty-one villages, large and small, have always been attached to the "Dhunpoore mines; and it has been found impracticable to separate the lease "of the villages from that of the mines. * * * Out of the total revenue of 1,901 "rupees paid by the farmer of Government, I found that he only collected 266 "rupees from the villages." *Ibid*, p. 154.

‖ "From the time of the Ghoorkha conquest (1803) up to the year 1838 the "produce of the Pokree mines had become more and more scanty, and when "(towards the close of the above year) these mines were handed over to Mr. "Wilkin, the actual revenue at which they were rated in the public accounts "amounted to 100 rupees per annum, and this small sum was eventually remitted "for that year, owing to the poverty and utter inability of the farmer to pay "the Government demand."—Mr. Commissioner Lushington, *Journal of the Asiatic Society*, xii. n.s. p. 457. *Official Reports on Kumaon*, p. 369.

¶ "The copper mines in Khurhai at present yield 15 rupees to the state, and "they are now being abandoned by their lessees. * * * The nature of the soil "in which the cupriferous deposits occur, renders the efforts at working the mines "a constantly recurring and nugatory labour, and the results the most puny and "contemptible."—Mr. Commissioner Batten, *Official Reports on Kumaon*. p.313.

** "The mine at present * * * yields hardly any proceeds. The last farmer "had great difficulty in paying the small jumma" (rent) "of 85 rupees per "annum."—*Ibid*, p. 281.

The Royalty received by Government from *Seera* during 1855 amounted to 35 rupees.

On certain deposits of Iron-ore in Bengal.

Many attempts to find iron-ore in the rich and extensive coal formations of Bengal, were made, as well by Government as by commercial associations and individuals, long before the extension of railway communication through India had increased the consumption of iron to its present rate.

(*a.*) On the picturesque southern slope of the Rajmahal range,* quartzose gneiss is overlaid by compact quartz-rock at Fitcooree;† and this is succeeded at Jherria by siliceous sandstone: which—grey in some places but brown in others—occasionally exhibits traces of carbonaceous matter, apparently of vegetable origin. The grey varieties contain mica; the brown probably take their hue from imbedded nodules of clay iron-stone, oxydulated iron-ore, and earthy brown iron-ore mixed with quartz. Generally these kernels are smaller than pease, though a few of them are as large as eggs; most of the ore occurs, however, in masses about half an inch in diameter. Slightly screened by a meager vegetation,‡ the rock yields readily to dis-

* Bishop Heber, *Narrative of a Journey through the Upper Provinces of India* (Edit. 1849), I. p. 119.

† "The country round Fitcoree is rather pretty, the hills covered with bamboo "and brushwood, and * * * rising rather suddenly from the elevated plains. "* * * Great crumbling masses of quartz protruded through the soil."

Dr. J. Dalton Hooker, *Himalayan Journals* (Edit. 1854), I. pp. 13, 14.

‡ "The vegetation of this part of the country is very poor, no good-sized trees "are to be seen, all is a low stunted jungle."—*Ibid*, p. 12.

integrating atmospheric influences; its lighter siliceous particles are quickly dispersed; but the ferruginous ingredients they once enclosed, still thinly sprinkle the surface.

Masses of quartzose breccia, and of amygdaloidal trap* mixed with earthy manganese, appear above the sandstone at intervals; and, overlying these, a bed of bituminous coal of excellent quality, from seven to twenty feet in thickness, is traced at the surface for more than half a mile; but, though within two hundred miles of Calcutta, it is wrought only to supply the neighbourhood.†

A few small heaps of iron-slag show that the ore has not been unnoticed; but when the experiment which afforded them was made, or what result was obtained, is alike unknown to the (Rajah) proprietor and his attendants: although a tradition yet remains that coal was employed in it.

(*b.*) For some distance on either side of the coal formation,‡ a while unsuccessfully wrought at Paunch-

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* Dr. J. Dalton Hooker, *Himalayan Journals* (Edit. 1854), I. p. 13.

† Mr. Homfray, *Journal of the Asiatic Society*, XI. N.S. p. 739. Mr. Williams, *Geological Report on Damoodah Valley* (Calcutta, 1850), p. 83.

‡ *Ibid*, p. 67.

Dr. Mc. Lelland, *Reports of the Geological Survey of India*, Calcutta, 1850. "The coal crops out of the surface; but the shafts worked are sunk through "thick beds of alluvium. The age of these coal fields is quite unknown, and I "regret to say that my examination of their fossil plants throws no material light "on the subject. Upwards of thirty species of fossil plants have been procured "from them."—Dr. J. Dalton Hooker, *Himalayan Journals* (1854), I. p. 7.

Professor Oldham, *Edinburg New Philosophical Journal*, II. N.S. 210.

Messrs. Hislop and Hunter, *Quarterly Journal of the Geological Society of London*, XI. p. 377.

maulee, about a mile north-west of Taldanga on the Barrukkar, the joints,—unusually numerous, short, and broad, in certain parts of the brown siliceous sandstone,—are lined with many thin laminæ of clay ironstone, which thus impress a brecciated character on the mass.* Spheroidal nodules,—each wholly or in great measure made up of many concentric bands,—of the same ore, also abound in the neighbourhood; but especially beneath the coal, in a bed of shale, from four to six inches in thickness. This was formerly wrought by the natives, as well from shallow shafts as in open-cuttings, throughout an area of perhaps seven acres; and the ore, so obtained, was smelted with charcoal.

South of the Barrukkar† the sandstones and coal of Paunchmaulee are succeeded by a large body of shale; through which clay iron-stone is disposed in small groups of irregular beds; but these are seldom either as much as three inches in thickness,‡ or more than ten feet in length and depth.

(*c*.) Many parts of the productive coal district near Raneegunge, are covered with coarse gravel; composed,

* Between Churra and Kala-panee in the Himalaya "the sandstone * * * is "curiously divided into parallelograms, like hollow bricks, enclosing irregularly "shaped nodules. I have seen similar bricks in the sandstones of the coal-"districts of Yorkshire: they are * * * probably due to some very obscure "crystalline action analogous to jointing and cleavage."—Dr. J. Dalton Hooker, *Himalayan Journals* (1854), II. p. 285.

† Mr. Williams, *Geological Report on the Damoodah Valley*, p. 67.

‡ Professor Oldham, *Report of the examination of the districts producing iron-ore in the Damoodah Valley and Beerbhoom* (Calcutta 1853), p. 4.

in great maasure, of brown siliceous sandstone,* but mixed, in some places, with small nodules of clay iron-stone.†

(*d.*) A bed of clay iron-stone,—ranging nearly east and west, and dipping with the surface, about 8° south,—is traced, at intervals, for perhaps a furlong on the ridge and twice that distance on the side of Akysá, a hill some eight miles north-east of Raneegunge.‡ At its outcrop the ore is about a foot in thickness; and,—occasionally quartzose,—is generally of good quality; towards the south, however, it declines as well in size as in value: and at the bottom of the slope is—though mixed with siliceous and other foreign substances,—only six inches thick.

(*e.*) Although the rock for some distance south of Akysá is covered by a thin layer of sandy soil, it reappears in the northern bank of a brook at Barrul Cajoor; not however in one broad bed, as before; but,—interlying a buff-coloured siliceous sandstone,—in several small ones; which within a few fathoms space unite, divide, vary in quality, dwindle, assimilate to the rock, die, and re-appear.

A few heaps of slag only remain to show that attempts at iron-smelting were formerly made in the neighbourhood.

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* Mr. Homfray, *Journal of the Asiatic Society*, XI. N.S. (1842), p. 743.

† Professor Oldham, *Report of the examination af the districts producing iron-ore in the Damoodah Valley and Beerbhoom.*

Major Baker, and Professor Oldham, *Extracts from the Records of Government*, No. 964 (Calcutta, 1853), pp. 1—8.

‡ Mr. Homfray, *Journal of the Asiatic Society*, XI. N.S. (1842), p. 745.

The sandstone containing small beds of clay iron-stone is succeeded by a seam of coal, which has been opened in several places; from this, however, attention has been withdrawn, by the richer and more accessible deposits of Raneegunge.*

* Excellent as the Bengal coal is for general purposes, experienced persons have failed in every attempt to obtain serviceable coke from it: the East Indian Railway Company therefore work their locomotives between (Howrah) Calcutta and the coal-mines with coke made of British coal (1855).

The Mining District of Chañarcillo in Chili, about fifty miles inland, is approached from the Pacific coast by a railway between Caldera, Copiapò—the capital of Atacama,— and Pabellon; and thence by a good, though circuitous, road across the mountains.

The isolated mountain of Chañarcillo, rises nearly four thousand feet above the sea and more than two thousand higher than the undulating plain surrounding and separating it from the lower Andes. Three strata of limestone and two of quartz, mixed with hornblende, bearing some 30° W. of N. and E. of S.,* alternate in its abrupt north-eastern escarpment; but dipping in the same way as—though less rapidly than—the surface, the upper two of them only crop out in its steep south-western slope. The perfect uniformity of this declivity is varied by the Morro de San José and Morro de Dolores *(Pl. I.)*, small conical hills, formed of successively smaller discs of rock, each traced for its entire circumference. These answer as well in composition and appearance as in situation and slope, to certain beds in the mountain, with which they were, perhaps, originally united.

When silver was found at *Descubridora (Pl. I.)*, in 1831† or 1832,‡ by Juan Godoi a muleteer whilst in

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* In June, 1857, Mr. E. Price Waring ascertained that the magnetic variation at Chañarcillo was 13° 50′ E.

† Mr. Domeyko, *Annales des Mines*, 4me. Série, xx. 1846, p. 453.

‡ Colonel Lloyd, *Report to the Foreign Office* (Woodfall, London, 1857), p. 7.

search of a lost animal, the district was overspread by a thicket of the *Chañar*,—a species of dwarf plum-tree,—and from that circumstance, was named Chañarcillo. A large mining population, attracted by the discovery, quickly stripped the surface of its wood ; so that neither tree, shrub, field, garden, nor even an occasional wild-flower, now relieves the brown and dreary monotony, the uniform and frightful barrenness, of this rich but horrible desert. Although the bed of every valley and glen is overlaid by a thick bed of shingle, pebbles, and gravel, deeply scored with ruts and other indications that the country was formerly well watered : there is neither a single spring in the district, nor is one streamlet now visible from the bleak summit of Chañarcillo ; except—perhaps twice or thrice in the year—when an occasional shower may for a few hours supply each ravine with a scantily trickling rill ; these are however quickly absorbed by the thirsty soil.

No water has even been drawn to the surface of any mine in the district; a little moisture, however,—derived, perhaps, from ascending vapour,—exudes from some of the rocks and veins, but it is immediately absorbed by other portions of the neighbouring strata.

Amongst the many mines opened at different elevations in Chañarcillo three only have been wrought deeper than the surrounding plain ; and these,—though more than two hundred and sixty fathoms below the surface,—are still far above the sea.

(A.) (*a.*) From the *Manto de Ossa*, at its summit, to *San Francisco viejo*, far down its slope, the mountain

is composed of limestone: which is more than one hundred and twenty fathoms thick in the north eastern outcrop; but,—from the upper inclining more rapidly than the lower face *(Pl. II.)*—presents a mere edge on the south-west.

Between the *Manto de Ossa* and *San Francisco viejo* the various beds and the lower side of this formation maintain, on the whole, a tolerably regular inclination—of about 5°—towards the south-west. At *Colorada*, however, an irregular boss some ninety fathoms in diameter and thirty in thickness *(Pl. II.,* K.) forms its nether portion, and thus extends the first limestone to within a few feet of the second. This protuberance is, like the little hills at San José and Dolores on the surface, constituted of many somewhat elliptical layers; which,—narrowest at greatest depths, and *vice versâ*,— closely resemble, as well in bedding as in composition, the mass of limestone they adjoin.

Although many *cross-veins heave* the *lodes* in Chañarcillo, only one of them displaces the rocks also.

At *San Francisco viejo*

the *Colorada lode*, bearing 38° E. of N. & W. of S., and dipping W. 65°–74°;
the *Waring lode*, bearing 38° E. of N. & W. of S., and dipping W. 64°–78°; and
the *Dolores Primera lode*, bearing 38° E. of N. & W. of S., and dipping W. 70°;
are all *heaved* about 9 fms. towards the *left-hand* and *greater angle** *(Pl. I.)*,
by the *Flucan*, which bears 30° W. of N. & E. of S., & dips N.E. 70°;

and on one—(its north-eastern or upper)-side (*hanging wall)*, the strata are twenty-one fathoms below their

* Cornwall Geol. Trans., v. pp. 5, 6.

counterparts on (its south-western or lower side) the other* *(foot-wall) (Pl. II.)*. South-west of the *Flucan* they dip, however, so much more rapidly than on the north-east, that their outcrop occurs at about the same level it would have maintained, had there been no displacement.

(*b.*) The first hornblendic formation separates the first from the second limestone; its upper and lower faces are therefore respectively parallel to the nether side of the one, and the surface of the other. As the former inclines about 5°, and the latter nearly 8°; the rock between them increases in thickness, from twenty-four fathoms at its north-eastern outcrop, to fifty-four at the *Flucan* in *San Francisco viejo*,—four hundred and eighty fathoms distant on its slope towards the south-west. Partaking, however, every irregularity in the contour of both bounding strata, it is sixty-five fathoms thick at *Desempeño*, but scarcely five between a deep depression of the upper and an opposite elevation of the lower limestone in *Colorada*. It suffers in common with the other strata, a vertical displacement of twenty-one fathoms at *San Francisco viejo*; and dips, like them, much more rapidly to the south-west than on the north-east of the *Flucan*. *(Pl. II.* N, O ; U, V.)

(*c.*) The first hornblendic formation is separated from the second, by a deposit of limestone, more highly

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* "The 'slip' or plane of dislocation hades, dips, underlays, or is inclined to "the vertical so as to pass under the depressed portion of the strata which are "displaced."—Professor Phillips, *Illustrations of the Geology of Yorkshire*, Part II. p. 111. Pl. XXIV. Fig. 16.

inclined than the first (*a.*), and marked on both faces, but especially on the upper, by undulations larger and more numerous than—with a single exception (*Pl. II.*, K.)—those in any other part of the series. A few portions of the surface have a north-easterly dip, but its general inclination is about 8° towards the south-west. The lower face, less deeply inflected, slopes more rapidly—perhaps 10°—the same way. Its thickness thus increases, from seven fathoms, beneath the *Manto de Ossa*, to nearly thirty, at the *Flucan* in *San Francisco viejo*.

(*d.*) A second formation of quartz and hornblende,—the largest member of this series,—divides the second (*c.*) from the third limestone (*e.*). Conforming in position to the rocks they adjoin,—its upper and nether faces dip respectively nearly 10° and about 4° south-west; and thus,—unlike the strata above,—it thins from one hundred and thirty-five fathoms, at its intersection towards one extremity of the district, to less than seventy at its displacement near the other.

About the middle of this formation a few beds of argillo-siliceous limestone (hydraulic lime), together less than two fathoms in thickness, maintain an approximate parallelism to the second limestone (*c.*) throughout Chañarcillo.

(*e.*) A third limestone formation,—unrecognized elsewhere,—is laid open in the lowest works of the deepest mines; but, as it has never been pierced, its thickness is unknown. Its surface dips about 4° towards the south-west; and—in common with the shallower

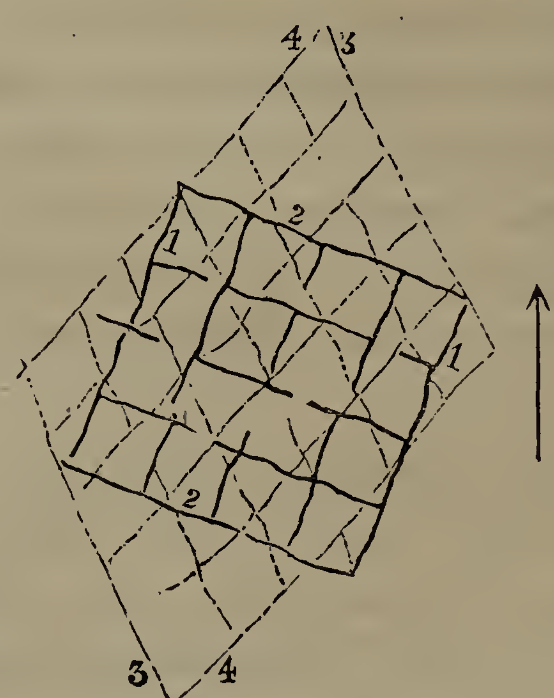
strata (*a. b. c. d.*) is displaced at the *Flucan* in *San Francisco viejo.*

(B.) Differences in structure, composition, and colour, characterize various beds in each of the five formations.

As Chañarcillo is now so dry and so destitute of vegetation, its rocks yield to disintegration but slowly; their structure is therefore well displayed at the surface. The first limestone (*a.*) is intersected by four series of joints, which bear

{ (1)..15°—30° E. of N. and W. of S.:
{ (2)..15°—30° S. of E. and N. of W.:
{ (3)..20°—30° W. of N. and E. of S.;
{ (4)..30°—45° N. of E. and S. of W.

A separate and distinct—approximately rectangular—structure is thus developed within the mass by each of the two pairs respectively. As however they interlace diagonally, the quadrangles articulated by one pair of joints, are subdivided into triangles,* by the other.



* "Beside the joints which approach to rectangularity, there are also others "which have an intermediate direction, and divide the blocks diagonally into

But as every joint suffers occasional interruptions* and deflections,† all the four series are seldom, if ever, alike pronounced in the same spot. The first and second, traced at short intervals throughout the district, are thus interlaid by the third only at *Colorada* near the middle of Chañarcillo, but by the fourth alone at *Descubridora* and the *Guias de Carvallo* on either side.

Although joints are in general merely closed seams, those in the crest of this mountain are so wide and so numerous, that,—filled with earthy‡ and stony *débris* of the adjoining rock,—they impress to some extent a fragmentary character on the mass.

(2.) The bed known in different mines as the *Manto de Ossa, Manto de Mandiola, Manto de los Cobos,* and *Manto de los Bolados* is usually from four to five, but occasionally as much as eighteen or twenty feet thick. The structure is generally cellular or vesicular;

" triangular masses, which in some situations seem to be rather more evident than " the rhombs."—*Cornwall Geological Transactions*, v. p. 170.

* " Occasionally a * * * joint * * * has only been found by the breaking of " the rock in working."

Mr. Enys, *London and Edinburgh Phil. Mag.* ii. (1833), p. 322.

† " But though the joints often preserve a tolerable regularity for some distance " they have frequent and considerable flexures, on the lines both of direction and " of dip; the opposite bounding planes of the jointed masses are therefore seldom " quite parallel."—*Cornwall Geological Transactions*, v. p. 170. *Ante*, p. 13.

‡ Mr. Domeyko's analysis of this earthy matter gave

Carbonate of lime	,335
Carbonate of magnesia	,052
Alumina and oxide of iron	,101
Silica	,170
Insoluble matter	,270
Water and loss	,072
	1,000

Annales des Mines, 4me Série, ix. p. 437.

and the joints—especially of the first and second series—are well developed; but they are fewer and narrower in this bed than in that which overlies it. The rock in different parts is either of a dark blue, brown, or buff colour, but white calcareous spar occurs at intervals, as well in small veins and isolated masses, as facing or filling its joints. Throughout this bed, especially where calcareous spar and earthy iron-ore abound, for some distance on either side of the *Candelaria*, *Colorada*, and *Descubridora** *lodes* the rock is sprinkled, its laminæ are interlaid, and its joints are invested or filled, with granules, filigrees, leaves, plates, and veins of native silver, mixed with the sulphuret, the chloride, and—less frequently—the chloro-bromide† of silver. In many such parts of the *Manto* this impregnation has been so general and so rich that the workmen have left only a few slender pillars of it to support the roof; and these are mostly pierced and scored in pursuit of rich veins and fibres. On every side of the caverns‡ thus opened, galleries, extended on lines of ore nearly coincident with the joints, form as they interlace an almost inextricable labyrinth.

Silver and silver-ore are thus scattered through limestone in this part of Chañarcillo, in the same manner

* One mass of native silver and silver-ore obtained from this *lode* was so large, that it was mounted and long used at the mine as a card-table.

† Mr. Domeyko, *Annales des Mines*, 4me Serie, IX. p. 453.

Colonel Lloyd, *Report to the Foreign Office, on the Mines of Copiapò* (London, 1857), p. 13.

‡ In such an opening on another formation at the *Guias de Carvallo* a horse whim has been set up and is worked by lamp-light.

as gold is dispersed through *Jacotinga** in Brazil; native copper through certain trap-rocks near Lake Superior; † tin-ore through slate at *Fatwork,* ‡ and through granite at *Carclaze,* § Raggy-rowal, || and *Balleswidden*¶ in Cornwall, at Geyer in Saxony, and Zinnwald ** in Bohemia; and the carbonate of copper through sandstone at West Felton †† in Shropshire, Alderley Edge ‡‡ in Cheshire, and Huidobro in Old Castile. §§

(3.) Many small cavities, incrusted with the chloro-bromide of silver and filled with calcareous clay, occur in a bed of ferruginous limestone, a few inches thick, which crops out at *Colorada* some thirty fathoms below the *Manto.*

(4.) A second thin bed of cellular limestone, even more ferruginous and clayey than the first, appears about fifty-five fathoms beneath it; and, as it intercepts the scanty portions of rare showers which, absorbed by the

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* "Micaceous iron Schist."—GARDNER, *Travels in the Interior of Brazil,* p. 493. *Postea.*

† Whitney, *Metallic wealth of the United States,* pp. 270, 287.

‡ *Cornwall Geological Transactions.* v. p. 120.

§ M. Jars, *Voyages Métallurgiques* (1765), III. p. 190. Professor Sedgwick, *Cambridge Philosophical Transactions,* I. p. 108; and (Address to the Geological Society, 18th February, 1831), *Proceedings of the Geological Society,* I. p. 283, *Philosophical Magazine and Annals,* IX. (1831), p. 284. M. M. von Oeynhausen and von Dechen, *Philosophical Magazine and Annals,* V. (1829), pp. 241–2. Dr. Boase, *Cornwall Geological Transactions,* IV. pp. 238–9. *Ibid,* V. p. 120.

|| *Cornwall Geological Transactions,* V. pp. 53, 235. ¶ *Ibid,* pp. 15, 235.

** Mr. Hawkins, *Cornwall Geological Transactions,* II. pp. 33, 43.

†† Murchison, *Silurian System,* pp. 39, 297. *Postea.*

‡‡ Murchison, *Silurian System,* pp. 39, 297. Mr. Higgs, *Cornwall Geological Transactions,* VII.

§§ *Postea.*

surface, are not dissipated in shallow galleries, is, therefore, called the *Manto de Agua*.

Alternations of crystalline, greyish-buff, with homogeneous, compact passing occasionally into slightly lamellar,* dark-blue limestone, make up the rest of this formation.

(*c.*) The second limestone exhibits similar alternations of buff coloured with blue, and crystalline with compact rocks; but contains neither fragmentary nor metalliferous beds.

The presence of silica and alumina† makes hydraulic lime‡ common to both formations.

(*d*—1.) A bed of siliceous limestone about nine feet in thickness, divides the second hornblendic formation parallel to its surface into nearly equal parts.

(*e.*) As deep as eighteen or twenty fathoms the third limestone is greyish blue and semi-crystalline; there, however, it suddenly assumes and thenceforward main-

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* "The various kinds of structure so frequently pass into each other in the "same mass, that it is oftentimes very difficult to observe where the one begins "and the other ends. When the rock has a compact texture, but more par- "ticularly if it be crystalline, it most commonly exhibits a massive structure; "and as it gradually becomes more and more fine-grained and homogeneous, it "generally acquires a proportionate degree of fissility."

Dr. Boase, *Primary Geology*, p. 104.

† "La roche la plus commune de cet étage est un calcaire argileux contenant "environ 40 p. 100 de résidu inattaquable par les acides, et ne renfermant que "quelques traces de magnésie.

M. Domeyko, *Annales des Mines* 4me Série, IX. p. 438.

‡ "When limestones contain considerable portions of silica and alumina, they "form what has been termed of late years *hydraulic lime*, and the mortars "made with them are called hydraulic mortars, of these, Parker's cement * * * "will *set*, as it is termed, or become solid in a quarter of an hour, either in air "or under water."—*Penny Cyclopædia* (Article Mortar), XV. p. 420.

tains a bluish-black hue and homogeneous structure. Its joints, meanwhile, are lined with amianthus.

(1.) About four fathoms beneath the surface of this formation the *Manto de Cachi*, a bed of calcareous spar no more than three inches thick adjoining the *lodes* and scarcely an inch elsewhere, is traced throughout the district.

The limestone strata are destitute of organic remains at Chañarcillo, but they afford them in the neighbourhood.*

(*b.d.*) The three strata of limestone, alternate with two groups composed in great measure of felspar, quartz, and hornblende.

In both these much white felspar often imperfectly but sometimes regularly crystallized, and dark green hornblende in small groups of prismatic crystals, are scattered through a basis of quartz and felspar; which, mostly mixed with hornblende, is generally green.

(2.) Acicular crystals of hornblende thinly interlace subordinate beds of quartz.

(3.) Greenstone, perhaps rather finer in grain below than above,† makes up the remainder of both groups.

Grains of iron pyrites are found at intervals, and particles of copper pyrites less frequently: calcareous spar, either as an ingredient of the rock or in small

* "Je n'ai pas trouvé de débris organiques dans toute la partie de la montagne "qui renferme les filons métallifères, quoiqu'on en trouve, comme je viens de "dire, autant sur le chemin de l'est, près de Molle, que sur le chemin du nord- "ouest, aux environs d'Ingenio."

M. Domeyko, *Annales des Mines*, 4me. Serié, IX. p. 435.

† *Ibid*, p. 437.

irregular veins, occurs sparingly throughout the series;* but epidote, similarly dispersed, appears in the lower beds only.

The presence of asbestus in minute flakes gives some portions a foliated character,† whilst in both groups others are massive; a crystalline structure is, however, common to all. A few of the numerous joints‡ present mere unctuous faces; but most of them are filled with calcareous spar, mountain-cork, mountain-leather, or amianthus.

No intermixture of ingredients takes place, no veins extend from one rock into the other, at any contact of the calcareous and hornblendic formations; every change of series is, on the contrary, sharply defined and immediate.

At *Colorada* all the strata are alike traversed from S.E. to N.W. by two parallel dykes, about four or five fathoms apart, dipping N.E.; one three or four, the other six or eight feet wide. Their chief ingredients,—felspar and hornblende,—are often porphyritic, disintegrated, and soft, in the calcareous series; but,—mixed with quartz,—are fine-grained and hard when intersecting hornblendic formations.

(*c.*) The most productive veins in Chañarcillo are—

* "On a trouvé cette roche composée de

"Carbonate de chaux..........	·076
,, de magnésie.......	·034
"Partie attaquable par les acides	·316 tenant ·08 de silice soluble dans la potasse.
"Partie inattaquable..........	·572
	·998."

M. Domeyko, *Annales des Mines*, 4me. Série, ix. p. 439.

† *Ibid*, p. 440. ‡ *Ibid*, p. 437.

	Direction.	*Dip.*
the *Descubridora lode*	18° E. of N. & W. of S.	W.
·· *Guanaca lode*	N.E. & S.W.	N.W.
·· *Guias de Descubridora branches*	18° E. of N. & W. of S.	W.
·· *Waring lode*	38° E. of N. & W. of S.	N.W.
·· *Colorada lode*	38° E. of N. & W. of S.	N.W.
·· *Caunter lode*	30° W. of N. & E. of S.	N.E.
·· *Dolores Primera, or Loreto lode*	38° E. of N. & W. of S.	N.W.
·· *Guias de Dolores Tercera branches*	35° N. of E. & S. of W.	N.W.
·· *Candelaria lode.*	20° N. of E. & S. of W.	W. of N.
·· *Bolaco lode*	20° W. of N. & E. of S.	W.
·· *Guias de Carvallo branches*	20° E. of N. & W. of S.	W.

Innumerable small *branches* spread from all, especially from the *Candelaria*, *Colorada*, and *Descubridora*, the largest and richest *lodes* in the district. Some of these connect neighbouring veins; but generally they dwindle and disappear, as well vertically as horizontally, within very short distances.

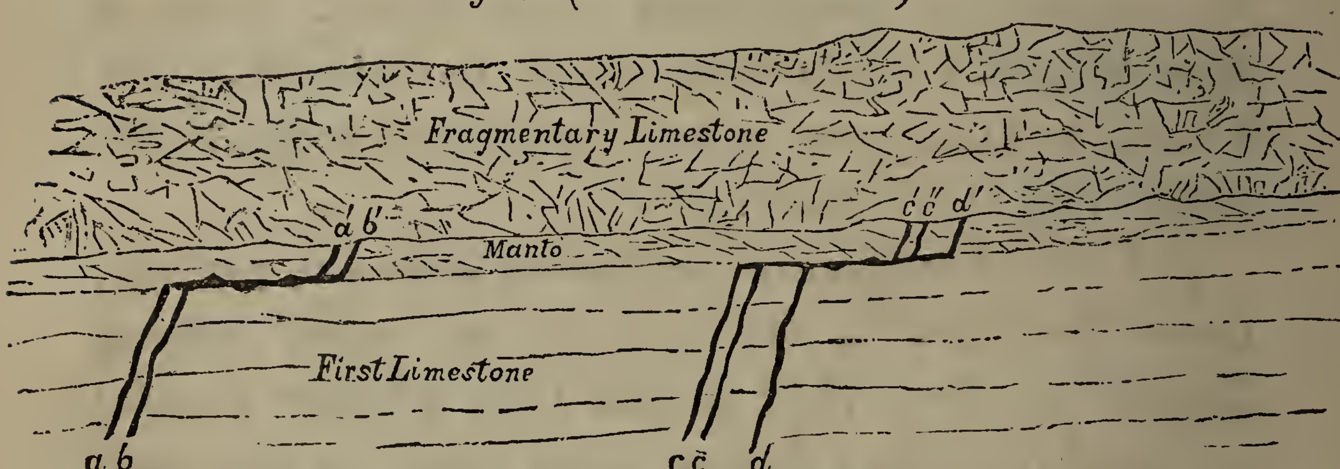
(1.) The directions of productive *lodes* are, perhaps, more diversified in this than in any other mining district; for they yield similar ores, whether parallel or transverse to the *(flucans)* veins which are composed of clay only.

(2.) The strata slope gently (4°—10°) to the south-west, but the *lodes* incline much more rapidly (64°—78°) towards points which—from the relations between dip and direction—are as various as their bearings; yet, with one exception only, are always west of the meridian.

The passage of *lodes* from one rock to another is, when uninfluenced by other circumstances, nowhere accompanied by remarkable changes of dip; save

between the *Manto de Ossa* and the limestone immediately beneath. There however the *lodes* do not directly enter one formation on leaving the other,—as elsewhere they do;—but, conforming awhile to the slope (10°—12° south-west) at their junction, pass for some way between them. Yet this coincidence is not of the same extent in every case; for after maintaining it,—the *Candelaria* (*d. d'. Fig.* 7.) for about fourteen fathoms and a half,—the *Colorada* (*a. a'.*) and *Waring* (*b. b'.*) for nearly eighteen fathoms and a half each,—and other *lodes* (*c. c'.*) for different distances, they all at length resume their normal inclinations (64°—78°).

Fig. 7. *(Transverse Section.)*



Scale 40 fathoms to the inch.

a. a'. Colorada lode. b. b'. Waring's lode. c. c'. c. c''. Guias de Descubridora. d. d'. Candelaria lode.

As the lower sides *(foot-walls)* are distended and more erect when *lodes* improve in quality,* they thus

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* " It is generally observed in the variations of the underlay or dip, that those " parts of lodes are richest which are nearest to perpendicular."

Mr. Thomas, *Report on a Survey of the Mining district from Chacewater to Camborne* (1819), p. 20.

" It is a remarkable fact that in every *lode*, whether it yields tin, copper, or " lead ores, the portions which are the most perpendicular are always the most " productive. This perpendicularity invariably takes place by an alteration in

become at the same time larger, richer, and more highly inclined.

(3.) Neither the dip nor the size of their poorer parts seems however to have much, if any, relation to the nature of the rocks they adjoin.

Although considerable portions of the *Colorada* and *Waring's lodes* maintain their characteristic breadths; this—the general fact elsewhere*—is an exceptional one in Chañarcillo; where—on the contrary—differences in width are great, frequent, and sometimes sudden.

The *lodes* are, however, largest and richest where they unite with minute veins, oblique both in direction and dip *(cruceros)*;† which—elsewhere mere joints—widen only as they approach the *lodes*, when in the thick-bedded dark blue limestone.‡

The *Candelaria lode* (*Fig*. 8. *c. c'*.) is seldom more than six inches wide where it crosses the hornblendic dykes (*a. a.' a. a.'*)§ of *Colorada*; but, though uniting with no other vein, it enlarges at the upper side *(hanging-wall)* to twelve or fifteen feet, immediately

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" the inclination of the lower or *foot-wall* of the *lode*, which becomes more vertical " *(bellying out)*; whilst the opposite, or *hanging-wall* may continue on the line " of its original dip: this change frequently produces, at one and the same time, " a more perpendicular appearance, and an enlargement of size in the *lode*."
Cornwall Geological Transactions, v. p. 231.

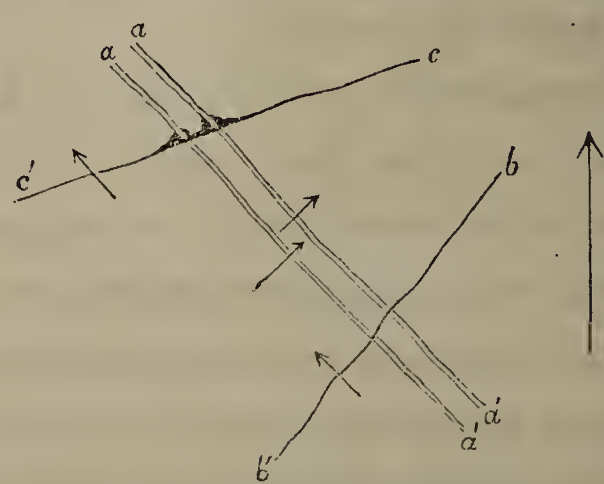
* " Every *lode* is generally characterized by a prevailing size, which, however, " may now and then fluctuate greatly, though, for the most part, it does so within " moderate limits."—*Cornwall Geological Transactions*, v. p. 241.

† " On appelle, au Chili, *croiseur* (crucero) tout filon secondarie qui s'unit au " filon principal, formant avec cellui-ci un angle quelconque."
M. Domeyko, *Annales des Mines*, 4me. Série, IX. p. 446.

‡ *Ante*, p. 14. § *Ante*, p. 80.

on entering the adjoining limestone. The *Colorada lode* (*b. b'*.) however traverses both rocks with but little change of size.

Fig. 8. *Plan.*



Scale 40 fathoms to the inch.

a. a'. a. a'. Dykes. *b. b'. Colorada lode.* *c. c'. Candelaria lode.*

The wider parts of *lodes* rarely consist of veinstone only, but enclose also blocks of the adjoining *(country)*, and thus assume a brecciated structure.* Their widest portions often *(take Horse)* split; † but such separate veins are seldom rich. On passing from one rock to another differing from it merely in hardness, the *lodes* often divide also into *branches;* which in the softer beds are generally less inclined, larger, and richer, but in the harder are flatter, smaller, and poorer than the *lodes* are when entire. *(Table III.)*

(4.) Where no joint separates the *lodes* from the rocks, the transition between them is so gradual, that the changes in their mineral character are scarcely perceptible.‡

* *Cornwall Geological Transactions*, v. pp. 210, 213, 229.

† *Ibid*, pp. 213, 231.

‡ Dr. Boase, *Primary Geology*, p. 179. *Cornwall Geol. Trans.* v. pp. 184, 186.

Where, however, the *lodes* differ much in structure and composition from the rocks adjoining them, they are often bounded on either side by the smooth *(walls)* faces of joints,* which—subject to, each its peculiar, flexures—are approximately parallel. Sometimes also the *lodes* are divided lengthwise by parallel joints,† but the portions in which they abound are seldom rich. And when the rocks are of lamellar structure certain *lodes* which traverse them occasionally partake it also.‡

Whilst the *lodes* traverse calcareous strata their earthy ingredients are for the most part granular limestone and calcareous spar; but in the hornblendic series they are principally felspar, quartz, and hornblende. When however magnesia, alumina, and silica occur, as some-

* Mr. William Phillips, *Transactions of the Geological Society*, II. p. 126. Mr. Carne, *Cornwall Geological Transactions*, II. pp. 50, 21. Dr. Boase, *Ibid*, IV. p. 448; *Primary Geology*, p. 176. Mr. Hopkins, *Lond. and Edin. Philosophical Magazine and Annals* (Third series), IV. p. 68; V. p. 130; IX. p. 369. *Edinburgh New Philosophical Journal*, XXII. (1836), pp. 156, 159. *Cornwall Geological Transactions*, V. p. 169.

† M. Werner, *New Theory of the formation of Veins* (English Translation), pp. 87, 107, 136, 214, 226. M. Daubuisson, *Des Mines de Freiberg*, I. p. 53. M. Jars, *Voyages Métallurgiques*, III. p. 93. M. De Luc, *Geological Travels*, III. pp. 266, 273. M. de Humboldt, *Political Essays on New Spain*, III. p. 229. M. Fournet, Etudes sur les dépôts Métalliferes, p. 43. Professor Sedgwick, *Cambridge Philosophical Transactions*, I. p. 108; Address to the Geological Society, 18th February, 1831, *Proceedings of the Geological Society*, I. p. 283; *Philosophical Magazine and Annals*, IX. (1831), p. 284; *Geological Transactions*, III. (N.S.) p. 483. Dr. Macculloch, *System of Geology*, I. p. 387. Mr. Westgarth Forster, *Section of the strata from Cross Fell, to Newcastle upon Tyne*, p. 191. Mr. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836), p. 93. Professor Phillips, *Treatise on Geology* (reprinted from the Encl. Britan.), p. 138. Mr. Burr, *Mining Review*, No. X. (1837), p. 66. Mr. (afterwards Sir H. T.) De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 339. *Cornwall Geological Transactions*, V. pp. 179, 182, 232. M. Domeyko, *Annales des Mines*, 3me. Série, XVIII. p. 3. Mr. Whitney, *Metallic Wealth of the United States* (Philadelphia, 1854), pp. 52, 53.

‡ Mr. Pryce, *Mineralogia Cornubiensis*, p. 95. *Cornwall Geological Trans.*, V. pp. 181, 232.

times they do, amongst the calcareous rocks, the *lodes* afford pearl-spar, amianthus, felspar, and quartz, in addition to their ordinary constituents; in like manner whenever lime forms either part of the rock or beds and veins in the hornblendic series, the *lodes* contain calcareous matter also. Thus to some extent all *lodes* partake in turn the nature of every rock they traverse.* These changes are much more conspicuous in the calcareous and hornblendic strata of Chañarcillo, than they are amongst granite and its congeners, in which similar ingredients† are so differently aggregated.

The contrast between such parts of the same *lodes* as traverse different rocks is much more manifest in their metallic than in their earthy constituents; for whilst contained in the hornblendic series they afford traces of blende and small quantities of iron pyrites only,‡ but when bounded by calcareous strata they yield silver and most of its ores in almost unexampled abundance.§

The *lodes* are however by no means alike rich in every part of the three limestone formations;‖ but

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* *Ante*, p. 23, *Note*,†

† Rev. J. J. Conybeare, *Annals of Philosophy*, vi. (n.s. 1823), p. 39. Dr. Boase, *Cornwall Geological Transactions*, iv. p. 391. De la Beche, *Geological Manual* (3rd. edition), pp. 440–443, 449–454. *Researches in Theoretical Geology*, pp. 295–300. Dr. Boase, *Primary Geology*, pp. 131, 205. M. Delesse, *Bulletin de la Société Géologique de France*, xv. (2me Série), p. 782. *Quarterly Journal of the Geological Soeiety of London*, xvi. (Translations and Notices), p. 11.

‡ M. Domeyko, *Annales des Mines*, 4me. Série, ix. pp. 437, 439. Colonel Lloyd, *Report to the Foreign Office, on the Mines of Copiapó* (1857), pp. 7, 8.

§ M. Domeyko, *Annales des Mines*, 4me. Serie, ix. pp. 437, 438. Colonel Lloyd, *Report to the Foreign Office, on the Mines of Copiapó*, pp. 7, 8.

‖ "La partie la plus riche du filon *(el beneficio)* suit de préference certains

contrariwise, when the rock is white, pale blue, or buff coloured, crystalline, and thin-bedded, they are little, if at all, more productive than they are in the hornblendic series.* This is strikingly exemplified at *Colorada ;* where the principal *lode*† is unproductive throughout the second hornblendic formation ; except in a thin interlying floor of limestone ; in that, however, it yields both vitreous silver-ore, and native silver.

But notwithstanding the bounding-planes of each formation by preserving the same level on either side of every *lode* afford proof that any motion, whether vertical or oblique, which may have taken place on one side of any *lode*, has extended in like manner to the other ;—portions of the first limestone, which, at twenty-five fathoms deep form opposite sides *(walls)* of the *Candelaria lode*, differ widely in appearance.‡

Many white and pale grey beds alternate in the south-eastern or lower side *(foot-wall)*, but a dark-grey, homogeneous thick-bedded limestone only occurs in the *(hanging-wall)* north-western.§ The former is straight and smooth, the latter crooked and rough. On both sides the two hornblendic dykes|| preserve their

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" couches privilégiées, et que ce sont ces couches qui rendent le filon métallifére " *(son los mantos que hacen pintar la veta).*"

M. Domeyko, *Annales des Mines*, 4me. Série, IX. p. 446.

* " The cleavage-planes of the schistose slates are almost invariably curved and " contorted whenever the rock is quartzose, and in such cases it is usually very " fissile, and the laminæ are highly inclined : either of these conditions is accounted " inauspicious."—*Cornwall Geological Transactions*, V. p. 225.

† The *Colorada lode. Table III.*

‡ *Ibid*, pp. 195-204. § *Table III.* || *Ante*, pp. 80, 83.

ordinary parallelism in direction and dip. In them the *lode* is about three feet and a half wide; and, partaking their nature, consists for the most part of disintegrated felspar and hornblende. On entering the limestone, however, the irregularities of its north-western side *(hanging-wall)* distend it to twelve or fifteen feet in width on either side of both dykes *(Table III., Fig.* 8; * and then its chief ingredients are calcareous spar, earthy yellowish brown iron-ore, vitreous and red silver-ore, and native silver. In such parts also the chloride and chloro-bromide of silver often encrust the joints.

In great part of the calcareous series *(a. c. e.*†*)* dark grey and deep blue tints prevail, which, more pronounced amongst the deeper than in the shallower beds, pass occasionally into bluish black in the third limestone at *Colorada* and *San Francisco nuevo.* These portions though sometimes granular, and often crystalline, are mostly massive in texture; and they afford every variety of lamellar structure. Isolated lumps and small irregular veins of calcareous-spar, are, at intervals, enclosed in the dark rocks. Hitherto the *lodes* have been rich whilst traversing the thick-bedded, homogeneous, deeply-tinted limestones only; but even in portions of these, some parts of them are barren.

Often, indeed, the other earthy ingredients are so much alike in both that it is difficult to distinguish the *lode* from the rock *(country)* at their contact; but

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* *Ante*, p. 83. † *Ante*, pp. 70-73.

as calcareous-spar sometimes forms continuous veins (*leaders**) in the *lodes* and their *branches;* it is therefore rather more abundant in them than in the dark-coloured limestone they traverse.

Such parts contain many drusy cavities, which are encrusted with calcareous-spar, pearl-spar, and quartz; but, though, spangled with rare crystals of silver and its ores, they are seldom rich.†

Many small hollows opening one into another, between blocks of limestone and ribs of calcareous-spar, form an irregular cavern,‡ perhaps twenty fathoms long, twelve fathoms high, and from three to fifteen feet wide, in the *Candelaria lode*, about half-way down the first limestone, at *Colorada.*§

Large though isolated portions of the compact calcareo-ferruginous matrix are impregnated with native silver in masses, veins, and ramifications, of

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* Mr. William Phillips, *Geological Transactions* (o.s.), II. p. 138. *Cornwall Geological Transactions*, v. p. 208.

† "Rare and curious crystalline minerals * * * are seldom found in connection "with large quantities of ore, although the *lodes* which afford them may be pro-"ductive in other parts."—*Cornwall Geological Transactions*, v. p. 206.

‡ "At *Dolcoath* a *vugh* 'from eighteen to twenty fathoms in length, three "fathoms high, and from four to nine feet wide' occurred in the *Main lode.* "Instead of a single large cavern, it, however, consisted of an infinity of small "ones, opening into each other; or perhaps it may be more correctly described "as a part of the *lode* filled with vesicular carbonate of iron. At the *Consolidated* "*Mines*, between the 110 and 120 fathoms levels, on *Taylor's lode*, a little west "of Taylor's shaft, a very extensive '*vough*,' or cavity was discovered; the size "was much greater than is commonly observed, being nearly forty fathoms in "length, and from one to two fathoms high; the direction was nearly horizontal, "the lode both above and below producing good ore." *Cornwall Geological Transactions*, v. p. 209, *Note.* See also Mr. Rule, *Cornwall Geological Transactions*, I. p. 225. Mr. Burr, *Mining Review*, No. VII. (July, 1835), p. 48. Mr. (afterwards Sir Henry Thomas) De la Beche, *Report on the Geology of Cornwall, Devon, and Somerset*, p. 324.

§ *Table III.*

every imaginable shape and size;—with the chloride of silver in like manner, but in less abundance;—and with vitreous and red silver-ore in the same way, though in still smaller proportions.* Whilst the *lodes* traverse certain strata their joints and crevices are often encrusted and filled with the chloride of silver and native silver;—less frequently with vitreous and red silver-ore and the chloro-bromide of silver;—and, yet more rarely, with the bromide, and the iodide of silver. Occasionally also the same minerals interlaminate the rock† for short distances on either side of the *lodes*.

Portions of all the *lodes* have been enormously rich.

At about one hundred fathoms deep in the first limestone (*a.*) great part of the *Candelaria lode*, for a length of thirty-five fathoms, afforded so much native silver and chloride of silver, mixed with chloro-bromic, vitreous, and red silver-ore, that it averaged sixty, and some portions of it yielded nine hundred, (Troy) lbs. of silver per ton.

The *Colorada lode*, whilst traversing the second limestone (*c.*) at one hundred and thirty five fathoms deep in *Colorada* and *Desempeño*, contains great quantities of comparatively inferior ore; so largely mixed, however, in some parts with native silver, the chloride, chloro-bromide, bromide, and iodide of silver,

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* M. Domeyko, *Annales des Mines*, 4me. Série, IX. pp. 438-439. Colonel Lloyd, *Report to the Foreign Office, on the Mines of Copiapó*, p. 13.

† "On voyait de tout petits feuillets des chloro-bromures disséminés dans le "roche encaissante."—M. Domeyko, *Annales des Mines*, 4me. Série, IX. p. 445.

‡ *Table III.*

and with vitreous and red silver-ore, that sixteen hundred tons selected from it gave sixty four thousand lbs. of silver; * of which one-eighth part was obtained by two miners in a month.

From this rich part of the *Colorada lode* several *(branches)* veins strike obliquely southward to *Waring's lode;* which, when alone, was barely an inch, but after their union with it was six inches wide. For five fathoms in length, and nine feet in height the *lode* maintained the same size, but it then entered a bed of white limestone and dwindled to its former dimensions. When small its only ingredient was calcareous spar; but during its enlargement this was mixed with the chloride of silver and vitreous silver-ore, and great part of it was so thickly intertwined with *(bar-silver)* native-silver; that,—too tough for extraction with the ordinary mining tools, and too porous to be blasted with gun-powder,—it was cut out bit by bit with chisels.†

* *Table III., Pl. II.* Q.

† *Table III.*

The besetting vice of Spanish America is so recklessly pursued in Chañarcillo, that on a pay-day groups of ill-clad native miners may be often seen playing at *pitch and toss* with silver dollars. When, also, the joint earnings of comrades, amounting to (a doubloon) an ounce of gold, are paid in a single coin, they sometimes settle by a *toss* which of them shall pocket the whole. Many would therefore starve were they not fed by their employers.

Although all works at the surface and all entrances to the mines are within high-walled court-yards; the mouth of every shaft and *(level)* gallery is also closed by a gate, which is never opened unless in presence of an overseer, who may be summoned by a bell rung on occasion from within the mine.

All ore brought to the surface is at once taken into small iron-fenced plots, within the walls; where, carefully guarded, it is *(dressed)* prepared for reduction.

Native workmen never leave either the mine or the *(dressing-floors)* ore-plots until both their clothes and their persons have been strictly examined. I can, however, merely allude to the dangerous and disgusting manner in which they often unsuccessfully, attempt to secrete small lumps of rich ore.

" As the Mexican miners are almost naked and are searched on leaving the

At a depth of thirty-eight fathoms in the first limestone (*a.*) the *Colorada* and *Waring lodes*,* when nearly parallel and about five fathoms apart, meet and intersect the *Caunter lode*, at horizontal angles of 68°—70°, but do not *(heave)* displace it. The chloride of silver is obtained, in small though rich *(bunches)* masses, from *Waring's lode;* and, mixed with native silver, from the *Colorada.* Similar ores have been so abundant in the *Caunter lode* that more than three thousand five hundred lbs. of silver were realized from the short range between its intersections.

The *Colorada* and *Waring lodes* unite at a depth of one hundred and thirty fathoms in the second limestone (*c.*); and, for an extent of about fifty fathoms, yielded the chloride, chloro-bromide, bromide, and iodide of silver in small proportions, and vitreous and red silver-ore mixed with native silver so largely, that the proprietors of *Desempeño* and *San Francisquito* shared therefrom the proceeds of more than fifty-three thousand lbs. of silver.†

Descubridora had been constantly and extensively wrought for five and twenty years, when, on preparing foundation for a storehouse, in the first limestone a few

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" mine in the most indecent manner, they conceal small morsels of native silver, " or red sulphuretted and muriated silver in their hair, under their armpits, in " their mouths, and in other parts of their persons. * * * It is a most shocking " sight to see * * * hundreds of workmen all compelled to allow themselves to " be searched on leaving the pit or the gallery. A register is kept of the minerals " found on them; * * * and in the mine of Valenciana at Guanaxuato the value " of these stolen ores amounted in thirteen years to £36,000 sterling."

M. DE HUMBOLDT, *Political Essay on New Spain*, III. p. 247.

* *Ante*, p. 81. *Table III.* † *Tables III. IV. Pl. II.* R.

feet only from the *lode*, a line of silver and silver-ore was unexpectedly laid open. This was the upper edge of a lenticular mass; which, about eighteen feet long, fifteen deep, and two and a half through towards the centre, was nowhere thicker than a crown-piece at its circumference. It afforded native silver, mixed and invested with the chloride, and chloro-bromide of silver in such rocks, that some of them like those obtained from the *lode* in 1831,-2,*—were temporarily used as card-tables.† Within two months the formation was exhausted; meanwhile more than forty thousand lbs. of silver were extracted from it.

But *(bunches)* masses of such richness, which occur at intervals only,‡ are generally surrounded by much larger bodies of inferior ore. Of this there remain, either still unbroken in the *lodes* or rejected at the surface, almost incalculable quantities, which might have been wrought to great advantage had Chañarcillo

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* *Ante*, p. 69. † *Ante*, p. 76. *Note.*

‡ "It appears that at the formation of veins * * * the distribution of silver "has been very unequal; sometimes concentrated in one point, and at other "times disseminated in the *gangue*, and allied with other metals. Sometimes in "the midst of the poorest minerals we find a very considerable body of native "silver, * * * which in place of being concealed in galenæ, or in pyrites in a "small degree argentiferous, or of being distributed through the whole mass of "the vein over a great extent, is collected into a single mass. In that case the "riches of a point may be considered as the principal cause of the poverty of the "neighbouring minerals. * * * In Mexico, as well as in Hungary, large masses "of native silver and vitreous silver-ore, appear only in a reniform shape; the "composed rocks exhibit the same phenomena as the masses of veins. When "we examine with care the structure of granites, syenites, and porphyries, we "discover the effects of a particular attraction in the crystals of mica, amphibole, "and felspar, of which a great number are accumulated in one point, while the "neighbouring parts are almost entirely destitute."

M. DE HUMBOLDT, *Political Essay on New Spain* (English Translation), III. p. 160.

been but sufficiently watered; under present circumstances, however, the richest portions of it only are available.

As no record is kept* either of ore from the mine, or of refuse whilst it is *(dressed)* made ready for reduction; the proportion of ore in the mass can be compared, neither with that in the *(dressed)* cleaned portion, nor with its produce.

The proprietor of reduction works near Chañarcillo, derives a trifling profit when a ton (avoirdupois) of ore, from his own mine, will yield twenty-three (troy) ounces of silver; but he can buy none, of that produce, at a price remunerative to the miner.

As some of the partners in *Colorada* are refiners of silver, they choose, as the Tinners in Cornwall anciently chose†, rather to divide the *(dressed)* cleaned ore, than to sell it amain and share its proceeds.

The following extract from accounts kept at that mine‡ may, perhaps, give a sufficient idea of the general produce.

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* " At Valenciana " in Mexico " they know to within a few pounds the quality " of *gangue* " (vein-stuff) " which daily goes out of the mine. * * * At the place " of assemblage in the great pits * * * two persons *(despachadores)* are seated " at a table with a book before them containing the names of all the miners " *(tenateros)* employed in the carriage. Two balances are suspended before them; " and two assistants judge the weight of each carrier's load. If the carrier " believes his load to be a light one he says nothing; but, on the other hand if " he thinks it heavier than usual he demands it shall be weighed, and the weight " thus determined is placed to his account."

M. DE HUMBOLDT, *Political Essay on New Spain*, III. p. 248.

† " The sandie Tinne * * * after often cleansing, they call black Tynne, which " is proportionably diuided to euerie of the adventurers."

CAREW, *Survey of Cornwall* (Edit. 1769), p. 12.

‡ 3550·5	grains................	= one	Spanish	Mark;
101·44	lbs. (avoirdupois)......	= one	,,	Quintal;
64·	quintals..............	= one	,,	*Cajon.*

Kelly, *Universal Cambist*, I. p. 320, 322.

1855.	Quantity of ore. lbs. (avoird.)	Oz. (troy) of silver per ton (avoir.) of ore.	Quantity of silver oz. (troy).	Monthly produce of silver. oz. (troy).
January	18,960	230	1,948	
	57,212	255	6,512	8,920
	1,622	637	460	
February ...	23,534	382	......	4,012
March	3,448	255	392	16,388
	40,170	892	15,996	
April	11,360	510	2,586	5,912
	29,214	255	3,326	
May	4,326	510	984	7,418
	37,734	382	6,434	
June	47,068	382	......	8,026
July	10,548	460	......	2,166
August	25,968	255	2,956	
	22,722	306	3,104	11,048
	21,910	510	4,988	
September ..	13,796	330	2,032	
	19,476	382	3,320	
	3,842	255	436	9,778
	29,214	306	3,990	
October	34,084	204	3,104	
	404	306	56	8,286
	22,518	510	5,126	
November ..	11,360	306	1,550	
	10,752	255	1,224	4,916
	23,534	204	2,142	
December ..	4,462	1,020	2,032	9,586
	34,894	485	7,554	
	lbs. 564,132			oz. 96,456

Average proportion of silver in the ore 1·172 per cent., or 383 oz. (troy.) per ton (avoirdupois).

1856.	Quantity of ore. lbs. (avoird.)	Oz. (troy) of silver per ton (avoir.) of ore.	Quantity of silver. oz. (troy).	Monthly produce of silver. oz. (troy).
January	48,284	357	7,696	
	6,492	3,825	11,086	30,042
	34,084	740	11,260	
February ...	30,836	255	3,510	
	3,854	7,140	12,284	25,494
	28,402	765	9,700	
March	64,920	382	11,070	16,890
	42,604	306	5,820	
April	26,780	102	......	1,218
May	21,504	127	1,218	
	18,258	765	6,236	10,808
	1,964	3,825	3,354	
June	15,418	306	2,106	3,952
	3,246	1,275	1,846	
July	49,908	357	7,954	9,340
	12,172	255	1,386	
August	——	——	——	——
September ..	40,576	127	......	2,300
October	17,040	255	1,940	
	21,910	306	2,992	6,390
	7,100	460	1,458	
November ..	10,346	635	......	2,932
December ..	50,314	280	......	6,290
	lbs. 556,012			oz. 115,656

Average proportion of silver in the ore 1·426 per cent., or 466 oz. (troy) per ton (avoirdupois).

Although these columns show the quantities of ore shared by the proprietors of *Colorada* in 1855—6, the produce they record is merely that of the native silver, the chloride, chloro-bromide, and other amalgamable compounds of silver *(metales calidos)* it contains. To this we must add the proceeds of smelting the vitreous, red, and other rarer ores *(metales frios)*; which—occurring in every metalliferous part of the *lodes*, but more abundantly in some calcareous strata than in others,—yield from ninety to one hundred and twenty *(troy)* ounces of silver per *(avoirdupois)* ton of ore; or from 0·275 to 0·367 per cent.

Taking the weight of *(dressed)* cleaned ore at unity, the proportion of silver extracted from it—

by amalgamation........	in 1855	was	0·01172*
,, ...	1856	,,	0·01426*
smelting..................		,,	0·00279*
		,,	0·00367*
or on an average..........	0·012964	to	0·012966†

a produce much smaller than that of earlier years.

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* "In most Countries the precious metals and their ores are weighed by different "Standards; but to facilitate comparison, it has been thought best to express "decimally the proportion of the one in an unit of the other everywhere."

† "The quantity of silver extracted from the minerals by means of mercury, "is in the proportion of 3½ to 1 of that produced by smelting. This proportion "is taken from the general table formed by the provincial treasuries, from the "different districts of mines in New Spain. There are however, some of those "districts, for example those of Sombrerette and Zimapan in which the produce "from smelting exceeds that of amalgamation."

M. de Humboldt, *Political Essay on the Kingdom of New Spain*, iii. p. 250.

Nearly one half the produce is native silver ;—about one-third is obtained from the chloride of silver,—and

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(*a.*) " The most abundant silver-ore in Chili is the chloride, which is associated " with the bromide of silver and native metal. Besides these, there are a great " variety of sulphurets and arseniurets. Their yield is from 0·003 to 0·008 ; the " richest contain 0·02 of silver."

Whitney, *Metallic Wealth of the United States*, p.173.

" The produce of the mines of Chili, has considerably increased of late years. " At eight leagues distance to the north-west of Mendoza the Cerro de Uspallata " contains masses so rich that they yield from 0·13616 to 0·2 of silver."

M. de Humboldt, *Political Essay on New Spain*, iii. p. 353.

(*b.*) " The contents of the minerals of Potosi " in Peru " have diminished in " proportion to the increase in the depth of the works.

" In 1545 a produce of from 0·4 to 0·45 was very common ;
" ,, 1574 the mean contents were from 0·04 to 0·045, and minerals which " yielded 0·25 were considered extremely rich ;
" ,, 1607 the mean contents were from 0·00625 to 0·000937.
" Since the commencement of the eighteenth century,—
0·000303 to 0·000404.

" The minerals of Potosi are consequently extremely poor, and it is on account " of their abundance alone, that the works are in such a flourishing state. It is " surprising to see that from 1574 to 1789, the mean riches of the minerals have " diminished in the proportion of 170 to 1, whilst the quantity of silver extracted " from the mines has only diminished in the proportion of 4 to 1."—*Ibid*, p. 373.

" The mean wealth of the minerals * * * in the mines of Pasco in Peru is " 0·000717."—*Ibid*, p. 166. *Note.*

" The mines of Cerro de Pasco * * * have grown sensibly poorer in descending. " * * * The tenor of the ores, which at the surface sometimes amounted to 0·3, " and averaged 0·0015, now hardly surpasses 0·0004."— Whitney, *Metallic* " *Wealth of the United States* (Philadelphia, 1854), p.169.

(*c.*) " In New Granada the depository of argentiferous minerals of Santa Anna " near Mariquita forms a bed in the gneiss and yields on an average 0·00407 of " silver." M. de Humboldt, *Political Essay on New Spain*, iii. p. 387.

(*d.*) " In Mexico, the mine of Valenciana, " in the total mass of minerals pro-" duced during the year 1791, afforded—

" ·0001	of rich minerals	(*polvillos and Xabones*)	which yielded	·111905 of silver ;
" ·0028	,,	(*apolvillado*)	,,	·046886 ,, ;
" ·0152	,,	(*blanco bueno*)	,,	·015630 ,, ;
" ·0215	of poor minerals	(*granzas, tierras ordinarias*, &c.)	,,	·001873 ,, ;
" and produced on an average........................				·005814 ,, ;

" In the district of Pachuca the produce of the Biscaina vein is divided into " three classes ; of which the richest yielded from " 0·003000 to 0·003302 of silver ;

,,	second ,,	,,	0·001250 ,, 0·001687	,, ;
,,	poorest ,,	about	0·000662	,, .

the remainder from vitreous and red ore, the chloro-

" In the district of Tasco
the minerals of Tehuilotepec yield about 0·001250 of silver;
those of Guautla .... 0·002250 " .

" Investigations made by Don Fausto d'Elhuyar, Director General of the Mines " of Mexico, and by several members of the Superior Council of Mines show the " mean riches of the silver minerals is from.......... 0·0018 to 0·0025; " and Don José Garces y Eguia, who directed extensive mining operations in " several districts, says *(Nueva Theoretica del beneficio de los metales* (Mexico, " 1802), pp. 121, 125), that 'the mean riches of Mexican minerals amounts only " to .... 0·001375.'

M. de Humboldt, *Political Essay on New Spain*, iii. pp. 162, 163, 165, 166.

(*e.*) " The silver furnished by the United States comes almost wholly from the " native gold of California. There is no proper silver mine within our territory, " although there are several localities where a small amount of this metal is " obtained in connection with lead ores.

In the State of New York the lead-ore of the Coal Hill mine affords traces of silver;

,,	New Hampshire	,,	Eaton	,,	,,	0·001000	,, ;
,,	,,	,,	Shelburne	,,	,,	0·001500	,, ;
,,	Connecticut	,,	Lane's	,,	,,	0·002000 to 0·003500	,, ;
,,	,,	the lead of	Middletown	,,	,,	0·000637 to 0·001911	,, ;
,,	Pennsylvania	the lead-ore (galena) of	Chester	,,	,,	0·000372 to 0·000506	,, ;
,,	,,	,, (phosphate of lead)	,,	,,	,,	0·000020	,, ;

,, North Carolina the lead of Washington mine, in 1844, afforded 0·007500,
,, 1851, ,, 0·008719,
of auriferous silver, which contained on an average 23·2 per cent. of gold.

Mr. Whitney describes the Upper Mississippi and Missouri lead districts very minutely; but he makes no mention of their having afforded silver.

Large quantities of native silver encrust the rich deposits of native copper, which are extensively wrought in many places, near the (Michigan) southern shore of Lake Superior; but great part of it is secreted by the workmen.

" The silver rarely form lumps of more than a few ounces in weight, although " some pieces weighing several pounds, and nearly pure, have been obtained. * * * " The amount of silver obtained from the Cliff Mine has sometimes been quite " considerable * * * it is mostly picked by hand from the coarse metal taken out " from under the stamp-heads." During the four years 1848-51 the proportion of silver was 0·0000135 the weight of ore *stamped.*

Whitney, *Metallic Wealth of the United States*, pp. 180; 266-305; 381-421.

Australia supplies Europe with large quantities of the sulphate of lead, which yields, on an average,
0·350000 its weight of lead, and
0·001071 ,, silver, beside a little gold.

Mr. J. Arthur Phillips, *Journal of the Society of Arts*, 27th April, 1859.

bromide, bromide, iodide, and other yet rarer combinations of the same metal.

(*f.*) " The silver-ore of Kongsberg in Norway was divided into four parts;
" whereof the first .... contained about ...... 0·66 its weight of silver;
,, second ...... ,, from 0·11361 to 0·118154 ,, ,, ;
,, third (picked) ,, about ... . 0·006816 ,, ,, .
The fourth (stamped and washed) is subdivided into three parcels;
of which the best .... contained about .... 0·004544 ,, ,, ;
,, average.. ,, from 0·00142 to 0·001704 ,, ,, ;
,, poorest.. ,, ,, 0·000284 ,, 0·000568 ,, ,, ."

M. Jars, *Voyages Métallurgiques*, II. p. 103.

The proportion of ore in each parcel is not mentioned.

" Those portions of rock which adjoin the veins and partake of their nature " *(faldband)* contain, occasionally, small quantities of native silver and the " sulphuret of silver; but seldom exceeding a 0·000071 part of the mass, they " will not repay the cost of the extraction."

M. Daubrée, *Annales des Mines*, 4me Série, IV. p. 258.
M. Durocher, *Annales des Mines*, 4me Série, XV. p. 378.

" At *Sala* the proportion of silver obtained is
0·014800 the weight of cleaned (*dressed*) galena, or
0·017200 ,, ,, lead."

M. Durocher, *Annales des Mines*, 4me Série, XV. p. 345.

" In the Banat auriferous pyrites from *Tsiklova* afforded
0·004677 its weight of silver."

M. de Chancourtois, *Annales des Mines*, 4me Série, X. p. 583.

(*g.*) " Near Chemnitz in Hungary one part of the *Spitalergang* yields
0·000040 its weight of silver, and
0·000005 ,, gold;
whilst another affords
0·000045 its weight of silver,
0·0000058 ,, gold, and
0·031970 ,, lead.
In the same district the *Thérèse* vein gives
0·000025 its weight of silver,
0·000005 ,, gold, and
0·004600 ,, lead.
The *Biebergang* furnishes
0·000059 its weight of silver, and
0·0000001 ,, gold.
The *Grünergang*, in the same neighbourhood, presents
0·000078 its weight of silver;
the mean produce of the district being
0·0000484 the quantity of crude ore extracted."

MM. Rivot & Duchanoy, *Annales des Mines*, 5me Série, III. pp. 358-363.
M. Pache, *Annales des Mines*, 4me Série, X. p. 595.

But all these ores are not alike plentiful, whilst the

" The silver ores of Nagybánia afford
0·000536 their weight of silver, and
0·000015 „ gold;
those of Neusohl
0·000915 their weight of silver,
0·000018 „ gold.
The lead ore of the same districts yields
0·000117 .. their weight of silver,
0·0000016.. „ gold, and
0·057 to 0·085 „ lead."
MM. Rivot & Duchanoy, *Annales des Mines*, 5me Série, III., pp. 365-6.

" At Przibram, in Bohemia, the cleaned *(dressed)* ore yields on an average
0·375000 its weight of lead, and
0·002228 „ silver."
M. de Hennezel, *Annales des Mines*, 4me Serie, I. p. 40.

(*h.*) " At Clausthal, in the Hartz, picked and sifted ore mixed with that which " had been stamped and washed, in proportion of about seven to three, affords
0·001016 its weight of silver, and
0·553 „ lead."
M. de Hennezel, *Annales des Mines*, 4me Serie, IV. p. 339.
M. de Bonnard, *Annales des Mines*, VII. p. 59.

(*i.*) " Throughout the district of Freiberg, in Saxony, the proportion of silver " obtained from cleaned *(dressed)* silver ore was, in

1762	0·000994	its weight. —	1781	0·001136	its weight.
3	0·000994	„	2	0·001230	„
4	0·000994	„	3	0·001172	„
5	0·001065	„	4	0·001349	„
6	0·000994	„	5	0·001136	„
7	0·001562	„	6	0·001136	„
8	0·001207	„	7	0·001207	„
9	0·001207	„	8	0·001207	„
1770	0·000639	„	9	0·008278	„
1	0·001136	„	1790	0·001349	„
2	0·001278	„	1	0·001420	„
3	0·000994	„	2	0·001349	„
4	0·000994	„	3	0·001349	„
5	0·000994	„	4	0·001349	„
6	0·000639	„	5	0·001278	„
7	0·001136	„	6	0·001349	„
8	0·001325	„	7	0·001491	„
9	0·001041	„	8	0·001562	„
1780	0·001207	„	9	0·001633	„
			1800	0·001846	„

" During these thirty-nine years, therefore, the average produce of silver was " 0·001211 the weight of the *(dressed)* ore from which it was extracted.

lodes traverse, even congenial portions of, the different limestone formations.

"In all other parts of the Erzgebirge the silver ores are so much richer; that
in 1763........ they averaged 0·010508,
,, 1799........ ,, 0·004544,
and during the interval ,, 0·008520."

M. Daubuisson, *Des Mines de Freiberg en Saxe* (1802), ii. pp. 122–4.
M. de Humboldt, *Political Essay on New Spain* (1811), iii. p. 167.

(*j.*) "Mines of lead-ore, rich in silver, were anciently wrought in Sicily and "Calabria, but they are now neglected."

M. Paillette, *Annales des Mines*, 4me Série, ii. p. 613.

(*k.*) "From the Sierra Almagrera, in Spain, cleaned (*dressed*)

fine-grained	galena from the	*Carmen*	mine yielded	0·717996	of lead &	0·010495	of silver	;
radiated	,,	,,	,,	0·630993	,,	0·006498	,,	;
black argillaceous	,,	,,	,,	0·220693	,,	0·003227	,,	;
,,	,, from	*Aguilas*	,,	0·637470	,,	0·003497	,,	;
large grained ..	,,	,, *Pietad*	,,	0·600000	,,	0·000997	,,	;
carbonate of lead	,,	,,	,,	0·415996	,,	0·001245	,,	.

"Assays of ore from other mines in the same district produced
from 0·600000 to 0·78850, and averaged .... 0·719770 of lead; and
" 0·000140 ,, 0·000900, ,, ... 0·000260 of silver:
massive carbonate of lead from Cape de Gat gave.... 0·002820 ,, ."

M. Paillette, *Annales des Mines*, 4me Série, ii. pp. 306, 318.

M. Berthier's analysis afforded
from 0·380000 to 0·790000, and averaged 0·618333 of lead;
,, 0·001000 ,, 0·010800, ,, 0·005910 ,, silver;
showed that the silver mixed with lead-ore in this district is a sulphuret, and proved that it contained no gold.—*Annales des Mines*, 4me Série, iii. p. 823.

M. Sauvage's assays indicate the proportion of silver to have been 0·004 the weight of crude ore from the mines of Almagrera.

Annales des Mines, 4me Serie, iv. p. 107.

"During the first six months of 1843, first class ore formed about 40, and "second quality perhaps 60 per cent. of the mass; and
the proportion of lead it afforded was from .. 0·200000 to 0·220000;
and ,, silver ,, nearly 0·002200:
but in the corresponding part of 1844 first class ore was only 12 or 15 per cent., and
the proportion of lead declined to .... 0·100000 or 0·110000;
and ,, silver ,, 0·001150 ,, 0·001250.
Galena obtained from slate is richer in silver than that from limestone in this district."

M. Pernollet, *Annales des Mines*, 4me Série, ix. pp. 65, 77; x. p. 256.

Mr. Michell, Director of very extensive Reduction Works in this district, during its richest period, found the
average proportion of lead .... 0·180000 the weight of ore;
and of silver .. 0·002204 ,, ,, ; or
0·012245 ,, lead.

Cornwall Geol. Trans., vi. p. 314.

In the third limestone the *lodes*, beside their earthy

At *Arrayanes*, near Linares, in the province of Jaen, the proportion of silver was between 0·000184 and 0·000214 the weight of cleaned *(dressed)* ore; or
0·000306 ,, lead.

At *Pozo Ancho*, in the same neighbourhood, the proportion was
about 0·000248 the quantity of cleaned ore; or
0·000367 ,, lead;

and this is nearly an average throughout the district.

Although this lead is smelted in Spain, the silver it contains is, for the most part, extracted either in England or in France; a small quantity only being separated at La Carolina, near Linares.—*From the MSS. of* HENRY THOMAS, Esq., F.G.S., *Director of Works at Pozo Ancho.*

The galena of Linares yields from 0·700000 to 0·720000 its weight of lead, and
,, 0·000280 ,, 0,000490 ,, silver.
M. LAN, *Annales des Mines*, 5me Série, XII. pp. 626, 628.

The mines of this district are mentioned by M. le Play, *Annales des Mines*, 3me Série, V. p. 184; M. Paillette, *Annales des Mines*, 4me Série, II. pp. 313, 317; Mr. Whitney, *Metallic Wealth* of the United States, p. 379; Professor Ansted, *Scenery, Science, and Art*, p. 141, Note.

"Argentiferous galena occurs in the Barranco de Val de Plata between Moncayo and Saragossa."—M. LEITÄO, *Annales des Mines*, 5me Serie, I. p. 109.

(*i.*) The mine of *Chalanches*, near Bourg d'Oisans in Dauphiny, afforded silver in the proportion of from 0·090888 to 0·181777 the quantity of the nickel, cobalt, and iron-ores with which, beside other ingredients, it was mixed.—M. DE BOURNON, *Journal de Physique* (1784), XXIV. p. 202. M. SCHREIBER, *Journal de Physique*, XXIV. pp. 380, 387. M. HÉRICART DE THURY, *Journal des Mines* (1806), XX. p. 46. M. LEFEBVRE, *Notice sur les Minerais et Usines des Chalanches d'Allemont et du Grand Clos* (Paris, 1852), pp. 4–10. M. LORY, *Bulletin de la Société Géologique de France*, 2me Série, VII. p. 541; XV. p. 13.

Cleaned *(dressed)* lead-ore from Montjean, near Vizille, in the same Province, produced 0·430000 its weight of lead, and
0·001154 ,, silver.
M. HÉRICART DE THURY, *Journal des Mines*, XXI. p. 267.

The argentiferous galena of *Pesey*, near Moûtiers, in the Department of Mont Blanc, yielded in—

1803	lead	0·370000	the weight of cleaned *(dressed)* ore.
,,	silver	0·001000	
1805	lead	0·540000	
,,	silver	0·001320	

Differently constructed furnaces were used in each of these years; during which equally discrepant results were obtained from ore of uniform quality.—M. LELIVEC, *Journal des Mines*, XX. pp. 442, 448. M. SCHREIBER, *Journal des Mines*, XXI. p. 58. M. BERTHIER, *Annales des Mines*, 3me Série, III. p. 549.

ingredients, contain vitreous and red silver-ore, blende,

The proportion of silver obtained from cleaned *(dressed)* lead-ore at *Pontgibaud*, in the Department of Puy de Dôme, was—

in 1846	0·001188 of its weight.	
,, 1847	0·001068	,,
,, 1848	0·001038	,,
,, 1849	0 001023	,,

MM. Rivot & Zeppenfeld, *Annales des Mines*, 4me Série, xviii. pp. 254, 443. M. Guényveau, *Annales des Mines*, vii. pp. 189, 192. M. Berthier, *Annales des Mines*, 3me Série, ii. p. 112. M. Fournet, *Annales des Mines*, 3me Série, ii. p. 139. Mr. Whitney, *Metallic Wealth of the United States*, p. 380.

The produce of lead ore from Carnoulès, near Alais, in the Department of Gard, was .... 0·343356 its weight of lead;
0·000718 ,, silver.

M. Lan, *Annales des Mines*, 5me Série, ix. p. 349. M. Boulanger, *Annales des Mines*, 3me Série, vii. p. 579. Professor Ansted, *Scenery, Science, and Art*, p. 20.

In 1823, the galena of la Lozère afforded on an average 0·001039 its weight of silver.—M. Marrot, *Annales des Mines*, xviii. p. 489. M. Lan, *Annales des Mines*, 5me Série, vi. p. 401; vii. p. 1.

Several mines in the Department of Aveyron yield argentiferous galena.—M. Blavier, *Journal des Mines*, xx. pp. 201, 209, 210, 223, 276, 285, 287. M. Boyse, *Annales des Mines*, 5me Série, ii. pp. 496, 500, 512.

"I lately obtained from * * * a mixed copper and lead ore from Pichiguet,

0·250000	its weight of	lead,
0·180000	,,	copper,
0·000827	,,	silver, and
0·000144	,,	gold."

Professor Ansted, *Scenery, Science, and Art*, p. 21.

At *Poullaouen*, in Finisterre, the cleaned *(dressed)* ore yielded,—

before 1807	0·600000	its weight of	lead, and
	0·000470	,,	silver:
in 1846, from 0·000200 to	0·000500	,,	silver.

At *Huelgoat*, in the same Department, the proceeds were,—

in 1807, from galena, 0·550000 its weight of lead, and
0·002400 ,, silver:
in 1846, ,, between 0·001000 & 0·002000 its weight of silver; and
from blende, ,, 0·000200 ,, 0·000400 ,, ,, .

In 1774, *Huelgoat* afforded an earthy black ore, from which M. Duhamel extracted............ 0 009380 its weight of silver.

In 1807 no silver seems to have been obtained at *Huelgoat* but that separated from the galena.

Previously to 1846, however, large quantities of native silver, of the chloride

and iron pyrites, sometimes mixed with small quan-

---

and chloro-bromide of silver, and of plumbiferous sulphuret of silver, had been wrought from the surface to about ninety-five fathoms in depth.

The plumbiferous sulphuret of silver yielded at times as much as		0·120000	the weight of ore.
the other ores	sometimes contained ,,	0.003500	
but the general produce was	from 0·000500 to	0·002000	

M. Daubuisson, *Journal des Mines*, xx. p. 352; xxi. pp. 83, 88. M. Pernollet, *Annales des Mines*, 4me Série, x. pp. 383–453. Mr. Whitney, *Metallic Wealth of the United States*, p. 380.

"A brown indurated oxide of iron which formed the upper part of a metal- "liferous bed in the higher grounds of Cronebane," in Wicklow, "was found to "contain minutely disseminated native silver, sometimes in extremely slight "filaments, but generally in particles quite imperceptible to the eye * * * * "It contained about thirty grains of gold in the ounce, equivalent to $6\frac{1}{4}$ per "cent., and hence the auriferous silver commonly sold for half a guinea an "ounce."—Mr. Weaver, *Geological Transactions*, v. p. 213.

In different parts of the United Kingdom lead-ores afford silver in various proportions: viz.—

		1856. Proportion of Silver in Lead-ore.	1856. Proportion of Silver in Lead.	1857. Proportion of Silver in Lead-ore.	1857. Proportion of Silver in Lead.
Ireland.					
Waterford ..	*East Shallee*............	....	....	0·000043	0·000070
	Gurtnadyne	0·000044	0·000070	0·000044	0·000070
	Garryard				
Wicklow	*Luganure & Glendalough* ..	0·000062	0·000106	0·000055	0·000106
Isle of Man.					
	Foxdale	0·000414	0·000568	0·000414	0·000566
	Laxey	0·001028	0·001439	0·001028	0·001439
	North Laxey	—	—	0·000338	0·000459
	South Manx	0·000316	0·000457	—	—
Scotland.					
Argyle	*Strontian*	0·000042	0·000060	0·000044	0·000060
	Cairnsmore	0·000022	0·000030	—	—
Dumfries	*Wanloch Head* (as corrected in 1857*)..	0·000149*	0 000205*	0·000137	0·000191
Perth	*Tyndrum*	—	—	0·000044	0·000067
Kircudbright.	*East Black Craig*	0·000060	0·000084	0·000010	0·000014
	Kirkudbright	0·000009	0·000012	—	—

Mr. Hunt, *Memoirs of the Geological Survey of Great Britain.*—Mineral Statistics 1856, pp. 39, 40; 1857, pp. 42, 43.

"All the lead raised in England and Wales contains silver in variable pro- "portions. * * * Half of that from Flintshire and Denbighshire contains from "$4\frac{1}{2}$ to $6\frac{1}{2}$ oz. (0·000137 to 0·000198), and the other half 9 or 10 oz. (0·000275 "to 0·000306) of silver per ton."

Mr. Pattison, *Reports of the British Association*, vii. (1836, Notices,) p. 50.

tities of native silver also; but they afford scarcely a

Wales.		1856. Proportion of Silver in Lead-ore.	1856. Proportion of Silver in Lead.	1857. Proportion of Silver in Lead-ore.	1857. Proportion of Silver in Lead.
Flint........	*Belgrave*	0·000024	0·000033	—	—
	Boddelwyddan	0·000156	0·000214	0·000170	0·000245
	Brynford Hall	0·000124	0·000169	0·000134	0·000184
	Brynsteddfod	0·000005	0·000007	—	—
	Caylan	0·000040	0·000057	—	—
	Comebine	0·003503	0·005193	—	—
	Deep Level	0·000088	0·000122	0·000088	0·000122
	Garreg	0·000140	0 000183	0·000131	0·000183
	Grosvenor Level	0·000208	0·000323	—	—
	Holywell Level	0·000198	0·000275	0·000258	0·000345
	Herward	0·000141	0·000196	0·000109	0·000153
	Maes-y-safn	0·000056	0·000076	—	—
	Michell	0·000043	0·000061	—	—
	Merllyn	0·000136	0·000189	0·000136	0·000191
	Mold	0·000111	0·000153	—	—
	Nant	—	—	0·000103	0·000146
	Nant-y-mawr	0·000130	0·000186	—	—
	Nant-y-gog	—	—	0·000090	0·000119
	Orsedd..................	0·000141	0·000196	—	—
	Pant-y-mwyn	—	—	0·000086	0·000115
	Penrhyn-ddu	0·000109	0·000158	—	—
	Pen-yr-henblas	0·000124	0·000171	0·000113	0·000160
	Pwllwheal	—	—	0·000045	0·000062
	Speedwell	0·000041	0·000057	0·000041	0·000058
	Talacre	0·000201	0·000292	0·000200	0·000275
	Talargoch { Maes-yr-erwddu	0·000134	0·000184	0·000200	0·000275
	Talargoch { Coetia Llys....	0·000226	0·000306		
	Tyrbach	0·000104	0·000151	—	—
	Tymaen	0·000043	0·000078	—	—
Denbigh	*Westminster*	0·000049	0 000067	0·000050	0·000069
	Plas Newydd	—	—	0·000179	0·000245
	Maes-y-safn	—	—	0·000062	0·000085
Merioneth ..	*Aberdovy*................	0·000136	0·000184	0·000138	0·000195
	Prince of Wales	0·000022	0·000031	—	—
Montgomery .	*Bryn-y-Fedwen*	—	—	0·000101	0·000152
	Cae Conroy..............	0·000280	0·000376	—	—
	Caylan	—	—	misprinted	in original.
	Dyliffe	0·000097	0·000112	0·000091	0·000127
	Dyfngwm	—	—	0·000040	0·000061
	Llanerchymawr	0·000095	0·000129	0·000101	0·000137
	Nant-y-mawr	0·000130	0·000178	—	—
	Nanty	0·000058	0·000080	—	—
	Rhiwarth	0·000179	0·000266	—	—
Cardigan	*Aberffrwydd*	0·000086	0·000140	—	—
	Abbey Consols..........	—	—	0·000127	0·000171
	Brongwyn	0·000060	0·000084	—	—
	Bronfloyd	—	—	0·000256	0·000307
	Bwlch Consols	0·000437	0·000570	0·000393	0·000570
	Cefn Brwyno	0·000065	0·000090	0·000069	0·000097
	Cwm Erfin	0·000298	0·000495	0·000388	0·000566
	Cwm Sebon..............	—	—	0·000775	0·001010
	Darren	0·000504	0·000812	0·000590	0·000918

trace of either the chloride or chloro-bromide of silver.

Whilst the *lodes* traverse the second limestone their

		1856. Proportion of Silver in Lead-ore.	1856. Proportion of Silver in Lead.	1857. Proportion of Silver in Lead-ore.	1857. Proportion of Silver in Lead.
Cardigan *(continued)*	*Dolwen*	—	—	0·001202	0·001695
	Eagle-brook	0·000174	0·000247	0·000130	0·000193
	East Darren	0·000321	0·000459	0·000348	0·000505
	Esgair Mwyn	0·000023	0·000033	0·000083	0·000117
	Goginan	0·000445	0·000612	0·000479	0·000704
	Lisburne Mines	0·000036	0·000052	0·000016	0·000022
	Llett-y-hen	0·000319	0·000489	0·000334	0·000490
	Llwynmalees	0·000284	0·000336	0·000214	0·000338
	New Lisburne	—	—	0·000140	0·000200
	Pantmawr	0·000128	0·000177	—	—
	Penycefn	0·000774	0·001084	—	—
	Taliesin	0·000195	0·000306	—	—
	Thomas United	0·000265	0·000377	—	—
	Ty Llwyd............	0·000098	0·000134	—	—
	Welsh Potosi	0·000175	0·000245	0·000131	0·000182
Caermarthen .	*Nant-y-Mwyn*	—	—	0·000070	0·000103
	Vale of Towey	—	—	0·000042	0·000064

Mr. Hunt, *Memoirs of the Geological Survey of Great Britain.*—Mineral Statistics. 1856, pp. 35–39; 1857, pp. 38–42.

" Lorsque les 21 quintaux contenoient un marc d'argent ou seulement 6 " onces," (0·000245 or 0·000183) " on pouvoit affiner le plomb avec avantage." M. Jars, *Voyages Métallurgiques* (1766), ii. p. 554.

" Silver is contained in the ore in different proportions, varying from 2 to 42 " ounces in the *fother* of 21 cwts." (0·000061 to 0·001285); " but 12 ounces" (0·000367) " may be considered as the general average. If 7½ or 8 ounces" (0·000230 or 0·000245) " can be extracted the lead is worth refining."

Mr. Winch, *Geological Transactions*, iv. p. 82.

See also Mr. Westgarth Forster, *Section of the Strata from Newcastle-upon-Tyne to Cross Fell*, p. 399.

" In Durham and Northumberland * * * many lead ores contain a much " larger portion of silver than the average of * * * the ores of Mexico and " Peru."—Rees, *Cyclopædia*, xxxii.—Silver.

" Of 22,000 tons of lead yielded in the district of Alston Moor, it is believed " that 16,000 tons contain silver at the rate of from 6 to 12 oz. per ton" (0·000183 to 0·000367), " and 6,000, from 3½ to 6 oz. per ton" (0·000107 to 0·000183),—" the average being about 5 oz. " (0·000153). " 4,700 tons from " Swaledale, Wharfdale, Pateley Bridge, &c., yield on an average only 2 oz. per " ton" (0·000061).

Mr. Pattinson, *Reports of the British Association*, vii. (1836) Notices, p. 50.

productive portions afford vitreous and red silver-ore,

		1856.		1857.	
		Proportion of Silver in		Proportion of Silver in	
		Lead-ore.	Lead.	Lead-ore.	Lead.
ENGLAND. Durham and Northumberland	*Bollyhope*	0·000301	0·000428	0·000267	0·000434
	Allergill	0·000146	0·000204	0·000196	0·000291
	Fallowfield	0·000208	0·000291	0·000208	0·000291
	Hallywell	0·000154	0·000263	0·000162	0·000245
	Derwent Mines	0·000182	0·000275	0·000150	0 000214
	Lunehead	0·000157	0·000214	0·000143	0·000214
	East and West Allandale and Weardale	0·000140	0·000184	0·000146	0·000183
	Brandon Walls	0·000123	0·000184	0·000131	0·000184
	Calves	0·000097	0·000177	0·000131	0 000184
	Stoneeroft	0·000133	0·000184	0·000133	0·000184
	Settling Stones	—	—	0·000066	0·000092
	Captain Cleugh	—	—	0·000100	0·000139
	Healey Field	0·000347	0·000490	0·000291	—
Cumberland..	*Stow Craig*	0·000921	0·001377	0·000920	0·001377
	Clargill Head	0·000942	0·001360	0·000928	0·001360
	Crossgill Head	0·000550	0·000926	—	—
	Grassfield	0·000287	0·000800	0·000630	0·000900
	Roughtengill	0·000584	0·000900	0·000581	0·000900
	Black Syke	0·000388	0·000612	0·000437	0·000612
	Driggitt	0·000398	0·000612	0·000398	0·000612
	Gallygill Syke	0·000358	0·000548	0·000388	0·000543
	Hudgill Burn	0·000365	0·000579	0·000369	0·000518
	Holyfield	0·000321	0·000490	0·000348	0·000489
	Nattras North Vein ..	0·000326	0·000459	0·000309	0·000451
	Low Birchy Bank	0·000283	0·000444	—	—
	Nattras Middle Vein ..	0·000381	0·000437	—	—
	Brigal Burn	0·000292	0·000433	0·000305	0·000427
	Bentyfield. East End, Sun Vein	0·000283	0·000428	0·000306	0·000428
	Dowpot Syke	0·000262	0·000410	—	—
	Windy Brow	0·000254	0·000376	—	—
	Goldscope	0·000105	0·000153	0·000257	0·000372
	South Crossfell	0·000152	0·000214	0·000139	0·000300
	Middle Tyne Green ..	—	—	0·000175	0·000262
	Foree Craig	—	—	0·000176	0·000246
	Green Banks	—	—	0·000167	0·000245
	Carrs West of Nent ..	0·000142	0·000240	0·000175	0·000245
	Calvert	0·000161	0·000245	0·000160	0·000242
	Dosey	0·000167	0·000245	0·000162	0·000242
	East Crossfell	0·000174	0·000245	0·000180	0·000242
	Allen's Clough	—	—	0·000150	0·000230
	Park Grove Sun Vein..	—	—	0·000158	0·000222
	Thorngill, West End ..	0·000131	0·000216	0·000157	0·000220
	Lady Vein	0·000156	0·000214	0·000158	0·000217
	Douke Burn, West End .	0·000155	0·000234	0·000151	0·000214
	Peat Stack Hill	0·000146	0·000213	—	—
	Thorngill, East End ..	0·000145	0·000214	0·000150	0·000213
	Tees Side & Metal Band .	0·000144	0·000214	0·000144	0·000211
	Patter Syke	0·000122	0·000214	0·000113	0·000209
	Rodderup Fell	0·000151	0·000214	0·000143	0·000204

in like proportions to those beneath; native silver is,

		1856. Proportion of Silver in Lead-ore.	1856. Proportion of Silver in Lead.	1857. Proportion of Silver in Lead-ore.	1857. Proportion of Silver in Lead.
Cumberland *(continued)* .	*Longcleugh, Rampgill, &c.*	0·000189	0·000275	0·000131	0·000184
	Blagill	0·000119	0·000184	0·000130	0·000184
	Wellgill Cross-vein	0·000121	0·000182	—	—
	Brownley Hill	0·000091	0·000122	0·000087	0·000122
	Douke Burn, East End ..	0·000082	0·000117	—	—
	Lee House Well	0·000905	0·001525	0·001078	—
Westmoreland	*Greenside*	0·000357	0·000506	0·000357	0·000490
	North Stainmore	0·000222	0·000306	0·000222	0·000306
	Brandlehow and Barrow .	—	—	0·000182	0·000260
	Keswick	0·000082	0·000122	—	—
	Nether Hearth	0·000061	0·000087	0·000060	0·000092
Yorkshire....	*Brathwaite*	0·000118	0·000168	0·000141	0·000209

Mr. Hunt, *Memoirs of the Geological Survey of Great Britain.*—Mineral Statistics. 1856, pp. 31–34; 1857, pp. 33–37.

"The lead of Derbyshire and Shropshire yields on an average from 1 oz. to "1½ oz. only of silver per ton" (0·000030 to 0·000046 its weight).

Mr. Pattinson, *Reports of the British Association,* vii. (1838) Notices, p. 51.

Mr. Hunt particularizes the lead-ore and lead obtained from Derbyshire, Shropshire, and Somersetshire, but makes no mention of silver extracted from any of it.—*Memoirs of the Geological Survey of Great Britain.*—Mineral Statistics, 1856, pp. 30, 31; 1857, pp. 32, 33.

"Betwixt the twelfth daie of August and the last of October in" (1294) "the "22 yeare of this king" (the first) "Edward's reigne there was tried and fined "out at Martinstowe in Deuonshire by times so much fined siluer, as amounted "to the summe of 370 pounds weight. In the 23 yeare of his reigne there was "fined at the place aforesaid 521 pounds and ten shillings weight of silver by "times. In the 24 yeare of his reigne, there were taken vp 337 miners, within "the warpentake of the Peake in Darbishire, and brought to Deuonshire, to work "there in those siluer mines: * * * and there were brought thence to London "the same yeare of siluer fined and cast in wedges 700 four pounds, thrée shil- "lings, and one penie weight. In the 25 yeare of his reigne, there were three "hundred and fourtie miners brought again out of the Peake into Deuonshire, "and out of Wales there were brought also 25 miners, which were all occupied "about those siluer mines, beside others in the selfe countrie of Deuonshire, and "other places."—*Holinshed's Chronicles* (Edit. 1807), ii. p. 545.

"Silver formerly was found in great plenty in the parish of Combe-Martin "(Miners being fetcht out of Derby-shire for the digging thereof) in the Raign "of King Edward I."—Fuller, *Worthies of England* (Edit. 1811), i. p. 270.

"The lead mines of Combe Martin were formerly celebrated for their silver."

Polwhele, *History of Devonshire,* i. p. 301.

"From the lead mines of Beer Alston a large quantity of silver has been "extracted. The produce of one vein averaged about 70 ounces" (0·002142) "to the ton of lead. Another vein * * * produced 170 ounces" (0·005102)

however, much more plentiful in them; and the

" of silver in the ton of lead. * * * During six weeks the silver extracted " from lead procured here exceeded six thousand ounces."

REES, *Cyclopædia*, XXXII. Article SILVER.

" The mines of Beer Alston and Beer Ferrers are remarkable for the length " of time for which, at different periods, they have been worked, and for the " quantity of silver which they contain; the silver in each ton of lead being " from 80 to 120 ounces" (0·002448 to 0·003672 its weight).

" Wheal Betsy lead mine in Mary Tavy, which had been worked about 80 " years ago, was re-opened about 1806. * * * The quantity of pig-lead ob- " tained from it is now between 300 and 400 tons in a year, and the silver from " 4,000 to 5,000 ounces, although a ton of the lead yields only 12 ounces" (0·000367).

" The proportion of silver in the ore of " a lead and silver mine at Newton " St. Cyres * * * is said to have been 30 ounces to the ton" (0·000918).

LYSONS, *Devonshire*, I. p. CCLXXXVIII.

Lead from shallow parts of the *Tamar Mines* contained about (one hundred and forty-five ounces per ton) 0·004437 its weight of silver; but from deep levels *(galleries)* it afforded from (thirty-five to forty ounces) 0·001071 to 0·001224 only.—PERCIVAL NORTON JOHNSON, ESQ., F.R.S., F.G.S., &c. *MSS.*

		1856. Proportion of Silver in		1857. Proportion of Silver in	
		Lead-ore.	Lead.	Lead-ore.	Lead.
Devonshire ..	*Tamar Silver Lead*	0·001306	0·002312	0·001114	0·002079
	South Tamar Consols ..	0·001407	0·002381	0·000788	0·001882
	Boringdon Consols	0·000871	0·001453	—	—
	East Tamar	0·000793	0·001076	0·001102	0·001714
	Huel Exmouth & Adams .	0·000380	0·000612	0·000523	0·000949
	West Collacombe	0·000318	0·000612	—	—
	Frank Mills	—	—	0·000129	0·000214
	North Huel Friendship ..	0·000198	0·000372	0·000059	0·000112
	Park, Huel Carpenter, Whitleigh, Silver Brook, & Wood Mine	0·000100	0·000146	0·000007	0·000010

MR. HUNT, *Memoirs of the Geological Survey of Great Britain.*—MINERAL STATISTICS. 1856, p. 30; 1857, p. 32.

" Silver found in Cornwall unmixed (I mean free from tin, copper, or lead) I " have never seen but once, and that was found native, about the bigness of a " walnut (of which I have part), in Huel-cock, a copper-work in the Parish of " St. Just." BORLASE, *Natural History* (1758), p. 209.

"Native silver, dentritic and in elongated octohedral crystals; and also " capillary native silver on arragonite, have been obtained from Levant, in St. " Just."—MR. CARNE, *Cornwall Geol. Trans.*, VI. (1846), p. 48. MR. GARBY, *Ibid*, VII. p. 87.

" In the vein formerly worked at Huel Mexico the ore appeared * * * as " insulated masses or nests, and beside native silver, corneous ore (muriate of " silver) was also met with."—DR. BERGER. *Geological Transactions*, I. p. 171.

chloride of silver abounds in shallower parts of the

Huel Mexico in Perran Zabuloe "produced considerable quantities of rich "horn-silver;" and "some fibrous native silver was found in the gossan."

Lysons, *Cornwall*, ccx. Carne, *Cornwall Geol. Trans.*, i. p. 121.

"About thirty years ago, a lode of silver was discovered near the sea, between "St. Agnes and St. Michael; and the mine, which was called Huel Mexico, "produced about £2,000 worth of ore."

C. S. Gilbert, *Historical Survey of Cornwall* (1817), i. p. 218. Rashleigh, *British Minerals*, ii. p. 19. Pl. xvi.

My grandfather was one of the unfortunate adventurers in this, the first, Cornish silver-mine.

"About fifteen years since, a few small bunches of exceedingly rich silver ore "(particularly horn-silver, or muriate of silver, a very rare production) were "raised in Cubert parish. Many of these pieces were finely crystallized: but "the most beautiful specimen is in the cabinet of John Williams, Esq., and has "been represented and described in that elegant work of Mr. James Sowerby, "the *British Mineralogy* for 1808."

C. S. Gilbert, *Historical Survey of Cornwall* (1817), i. p. 219.

"At Herland in Gwinear the silver cross-course between 110 and 142 fathoms "deep afforded for some distance on either side of the Main *(Manor)* lode, which "it intersects, a mixture of galena, native bismuth, grey cobalt-ore, vitreous "silver-ore, and native silver; of which about 108 tons were raised. The richest "mass of silver-ore was found at but two fathoms above the level at which it "disappeared."—The Reverend Malachy Hitchins, *Phil. Trans.*, 1801, pp. 159-163. Dr. Berger, *Geol. Trans.*, i. p. 171. William Phillips, *Geol. Trans.*, ii. p. 152. Lysons, *Cornwall*, ccx. Polwhele, *Cornwall*, iv. p. 134. C. S. Gilbert, *Cornwall*, i. p. 218. Carne, *Cornwall Geol. Transactions*, i. p. 121; ii. p. 113. Rees, *Cyclopædia*, xxxii.: Article Silver. Sir H. T. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 288.

The quantities of ore,—the proportions of silver they contained,—and the sums realized by their sale, were:—

Date.	Weight of ore, 20 cwt. to the ton.				How disposed of.	Proportion of silver.	Price of ore per ton.			Amount.		
1799.	tons	cwt.	qrs.	lbs.			£	s.	d.	£	s.	d.
Aug.	17	10	0	0	Smelted at the mine ..	0·005407	———			928	6	4
					Sold to—							
,, 20th.	2	0	0	0	Birmingham Co.	0·006120	48	0	0	96	0	0
Sept. 30th.	3	1	2	17	Philip George & Co. ..	0·006334	50	0	0	154	2	6
1800.												
Jan. 20th.	19	18	0	0	ditto ..	0·006334	50	0	0	995	0	0
,, 30th.	1	12	0	0	Joseph Edwards & Co..	0·006334	50	0	0	80	0	0
Feb. 20th.	3	0	3	25	Riddle & Co.	0·006334	50	0	0	152	8	8
April 5th.	20	5	3	13	Philip George & Co. ..	0·006334	50	0	0	1014	13	3
,, 24th.	6	1	0	0	Riddle & Co.	0·006334	50	0	0	302	10	0
,, 26th.	12	6	3	0	Philip George & Co. ..	0·006334	50	0	0	616	17	6
,, ,, .	0	4	3	7	Birmingham Co.	0·021236 average.	Different rates..			42	19	3
Forward .	86	1	0	6						£4382	17	6

series. The iodide and bromide of silver,—nowhere

	tons	cwt.	qrs.	lbs.			£	s.	d.	£	s.	d.
Forward .	86	1	0	6	....	....	....			4382	17	6
1800. Aug. 5th.	21	18	1	15	Philip George & Co. ..	0·006334	50	0	0	1095	19	0
„	1	12	0	0	Edwards & Harvey ..	0·006334	50	0	0	77	5	6
„	6	4	1	7	Ditto ..	Litharge.	——			93	6	0
Total ..	115	15	3	0	....	......	....			£5649	8	0

From the MSS. of Alfred Jenkin, Esq., *the Lord's Agent.*

After a while the works were abandoned; but they were resumed in 1825, and the *Silver cross-course*, again wrought, afforded small quantities of silver-ore at a greater depth *(Cornwall Geol. Trans.*, v. *Table XXXIV.)*; viz.—

Date.		Quantity of ore. cwt.	qrs.	lbs.	Proportion of silver.
1833.	Feb.	4	2	0	.... 0·012546
	Aug.	7	1	0	.... 0·001714
	„	4	2	0	.... 0·004162
	„	2	2	0	.... 0·006334
	„	0	2	0	.... 0·006946

From the MSS. of Edward Michell, Esq, *Mayor of Truro.*

At the adjoining mine, "Huel Alfred, in 1813, some native silver was found, "appearing as if plated on the copper ore; but in so small a quantity as not to "be worthy of notice."—Carne, *Cornwall Geol. Trans.*, i. p. 123.

"Native silver is accompanied by red, grey, and black silver ore, in Huel "Alfred.—William Phillips, *Mineralogy* (3rd Edit.), p. 285.

"Huel Alfred, in Phillack, has produced native silver in green carbonate of "copper."—Michell, *Manual of Mineralogy* (Truro, 1825), p. 20.

"Huel Ann, in Phillack, furnished, in 1814, a small bunch of blackish grey "silver ore containing a great deal of arsenic and spathose iron, and accompanied "by native silver, at the sixty-five fathoms level, in an east and west copper lode. "In the seventy-five fathoms level, the silver ore appeared in the midst of the "copper lode, as a separate lode, from two to five inches wide. * * * Some fine "specimens of fibrous native silver were found in this level; but these, as well "as the ore, proved of very short duration."

Carne, *Cornwall Geol. Trans.*, i. p. 124; ii. pp. 105, 120.

"Huel Ann has produced native capillary silver, with surprising fineness of fibre, "in tin-white and grey cobalt, and grey silver in arsenical pyrites."

Michell, *Manual of Mineralogy*, p. 20.

"In Dolcoath, in 1810, some grey silver ore intimately united with cobalt ore, "together with a little native silver, were found in the sixty fathoms level in the "copper lode, very near a small cross-course."—Mr. Carne, *Cornwall Geol. Trans.*, i. p. 122. Wm. Phillips, *Mineralogy* (3rd Edit.), p. 288. Michell, *Manual of Mineralogy*, p. 20.

"In the *Entral South lode*, at *Dolcoath*, much native silver, as well as vitreous "and red silver ore, were mixed with galena, blende, and with still larger quan- "tities of iron and copper pyrites, quartz, and slaty clay."

Cornwall Geol Trans., v. p. 66, *Table. L.*

common—are in Chañarcillo peculiar to this formation.

The silver ores sold from this part of the mine were :—

Date.	Quantity of ore. 20 cwt. to the ton. tons	cwt.	qrs.	Proportion of silver.	Price of ore per ton. £	s.	d.	Amount. £	s.	d.
1833. Nov. 23rd. ..	1	15	1	0·011995	99	10	6	175	8	2
" ..	1	0	3	0·002478	16	13	10	17	6	4
1834. July	4	4	0	0·008476	69	1	5	290	2	0
"	3	3	0	0·004039	30	11	0	96	4	6
Aug. 21st ..	4	16	0	0·006273	49	18	1	239	10	8
1835. Jan. 6th	3	3	0	0·007650	61	13	4	194	5	0
"	4	19	0	0·005202	40	9	6	200	7	1
"	1	13	0	0·003978	29	19	0	49	8	4
12th	2	12	2	0·005875	46	9	0	121	18	9
"	4	0	1	0·002846	20	2	5	80	14	6
1836. Jan. 12th ..	1	10	3	0·002968	20	19	0	32	4	2
" ..	0	12	2	0·006334	50	8	0	31	10	0
" ..	0	4	1	0·049909	430	3	4	91	8	2
Nov. 23rd ..	1	12	3	0·002111	13	6	8	21	16	8
" ..	2	4	2	0·001928	11	18	1	26	9	8
" ..	0	17	0	0·003764	27	19	7	23	15	7
" ..	0	18	0	0·000734	1	9	6	1	6	6
" ..	0	11	0	0·010220	84	5	9	46	7	1
	39	17	2					£1740	3	2

beside which, above one thousand three hundred Pounds were realized from ore smelted at the mine. *Entral South lode* has therefore yielded more than three thousand pounds worth of silver.—*From the MSS. of* Captain Charles Thomas, *Manager of Dolcoath.*

" The noble family of Basset, the proprietors of the land, preserve as an heir-" loom a splendid piece of plate made of silver raised at *Dolcoath;* which was " presented to the late Lord De Dunstanville by the adventurers in that mine, as " a testimony of their gratitude for his liberal relinquishment of the Lord's *dues*, " whenever the poverty of the concern rendered an increased outlay necessary."
Cornwall Geol. Trans., v. p. 66, *Note.*

The silver-ore of *North Dolcoath*, an adjoining mine, afforded, during 1859-60, 0·003011 its weight of metal.—*MSS. of* Captain Joseph Vivian, *Manager of North and South Roskear, &c.*

Mr. Carne states that at Huel Basset, in Illogan, a small cross-course traversing the lode, afforded, in 1813, vitreous silver-ore, some of which yielded (0·018360 its weight) six hundred ounces of silver per ton, at and within about six feet on either side of the intersection (*Cornwall Geol. Trans.*, i. p. 124); and Mr Wm. Phillips observes that silver-ore worth three thousand Pounds was obtained there. *Mineralogy* (third Edition, 1823), p. 236.

Mr. Martyn, the sole survivor of those who at this time and long afterwards were agents at *Wheal Basset*, says that during his connexion with that mine, silver-ore was discovered but once,—that the quantity was very trifling,—the quality such that for several years no purchaser could be found,—and at length

Both the *lodes*, and the layer of rock (the *Manto)*

---

it realized only a small sum. He adds that there was neither record nor tradition of any similar discovery having been made previously.

The late John Williams, Esq., of Scorrier House, had the entire direction of *Wheal Basset* during this period. His account books, examined in aid of this enquiry, fully confirm the accuracy of Mr. Martyn's recollection; and show that the silver-ore raised in 1813 was not disposed of until 1827, when it was sold for £15 : 12 : 4 only.

Silver-ore is thinly dispersed through siliceous earthy brown iron-ore *(gossan)* in the shallower parts of Treskerby near Redruth. In 1827 a parcel of it realized £15 : 14 : 4.

At the same time a smaller quantity of similar ore was sold from the adjoining mine of *North Downs* for £3 : 4 : 9.

William Williams, Esq., *of Tregullow. MSS.*

The ancient mine of *Bal-dhu*, in Kea (Davies Gilbert, *Cornwall*, ii. p. 302), affords enormous masses of the same ore; which have been, from time to time, largely wrought for the scattered particles of silver-ore they contain.

" Huel Duchy in Calstock * * * one of the principal silver-mines * * * has " already produced about £4,000, and promises to be yet more profitable."

Lysons, *Cornwall*, ccx.

" Wheal Duchy in Calstock (discovered in searching for copper) has been " worked with success. The whole lode is from 6 to 12 inches wide—the part " containing silver from 1 to 4. It runs E. & W., the direction of other similar " veins in the neighbourhood. Some of the ores contain from 60 to 70 parts in " 100" (0·6 to 0·7) " of pure silver. About £5,000 worth of silver, a year or " two ago, had covered the expense of the undertaking in its early stages."

Polwhele, *Cornwall*, iv. (1816), p. 134.

" Some silver works are still kept open at Calstock, by the name of *Wheal* " *Duchy*, from which the cup presented to the Duke of Cornwall, in the year " 1812, by Benjamin Tucker, Esq., was extracted."

C. S. Gilbert, *Cornwall*, i. p. 219.

" At Huel Duchy, near Callington, in a lode inclining to the north-east and " south-west, and from one to three feet wide, in which the adventurers were " searching for copper, detached lumps of silver-ore, and small bunches of native " silver were found at the adit. In the ten fathoms level, there was a regular " course of silver ore, accompanied by native silver, for nearly three fathoms " in length, yielding above £200 worth per fathom. This was its richest part. " In the twenty fathoms level, some native silver, and bunches of silver ore were " found, but the lode had here declined in value. In the next deeper level the " silver was exhausted. The ore consisted chiefly of red and grey silver and black " oxyd of silver.—The value of the silver produced was about £3,000."

Carne, *Cornwall Geol. Trans.*, i. p. 122.
Michell, *Manual of Mineralogy*, p. 21.

After this the mine remained many years unwrought; but in 1833 it was re-opened under the name of *Wheal Brothers*. De la Beche, *Report*, p. 613. *Cornwall Geol. Trans.*, v. p. 140; *Table XCIII.*

which deflects them from their ordinary dip in the

" Portions of argentiferous earthy brown iron-ore *(silver gossan)* left by the " former adventurers in shallow parts of the mine, were now extracted and sold " for between £150 and £200 per ton.

" So greatly does the ore differ in quality, that some parcels of it brought no " more than £2, and others,—containing 0·059976 their weight of silver,—as " much as £500 per ton in the market."—CAPTAIN KNOTT, *MSS.*

" At the 30-fathom level masses of native silver, weighing many pounds each, " occurred in a part of the *lode* which was worth from £500 to £600 per fathom. " But great part of the ore when brought to the surface contained only from " (eight to ten ounces) 0·000245 to 0·000306 its weight; although when *(dressed)* " prepared for sale it yielded (sixty ounces per ton of ore) 0·001836 its weight " of silver."—PERCIVAL NORTON JOHNSON, ESQ., F.R.S., F.G.S., &c., *MSS.*

" *Wheal Sisters*, opened also in 1833, on an eastern part of the same *lode;* " afforded ore which, resembling for the most part that of *Wheal Brothers*, con-" tained from 0·00459 to 0·07344 its weight of silver. Portions of it were, " however, mixed with from 0·15 to 0·2 their weight of lead. Small quantities " of the silver-ore were sold at twenty shillings a pound; and some parcels found " a market at from £400 to £500 per ton, but the ordinary price was between " £30 and £50."—CAPTAIN KNOTT, *an Agent of the Mine, MSS.*

Wheal Saint Vincent yielded great quantities and many varieties of silver-ore from a parallel *lode* south of that wrought at the same time in the neighbouring mine of *Wheal Duchy;* but, no longer affording profit, it was closed in 1824. If accounts of the produce still exist they are inaccessible.

In 1835 the works, then named the *East Cornwall Silver Mines*, were re-opened, but, after an unsuccessful trial of about two years, they were again abandoned. During that period they yielded the undermentioned ores :—

Date.		Weight of ore. Tons.	cwt.	qrs.	lbs.	Proportion of silver.
1837.	Sept.	0	17	1	0	...... 0·002708
	,, ...	0	6	3	0	...... 0·009118
	,, ...	0	4	0	14	...... 0·030263
		1	8	0	14	

EDWARD MICHELL, ESQ., *Mayor of Truro, MSS.*

" The same mine was opened a third time in 1848, under the name of *Wheal* " *Langford.* Silver-ore becomes less and lead-ore more abundant as the mine is " deepened (*Postea*, p. 119). For several years the ore afforded from 0·001224 to " 0·060466 its weight of silver, and its price ranged between £10 and £550 per " ton. In June, 1855, Tons 2 : 6 : 2 : 6 (sold at £509 per ton) realized " £1184 : 15 : 9."—CAPTAIN KNOTT, *an Agent of the Mine, MSS.*

" *Wheal Mexico*, wrought to an inconsiderable depth on an eastern part of the " same *lode*, during 1847-8,—afforded the chloride of silver largely mixed with " slaty clay, granular quartz, and the carbonate of iron. Some portions of the " ore contained 0·001224, others 0·026316, their weight of silver. The prices

first limestone, contain native silver largely mixed

"generally ranged from £5 to £200 per ton; but small quantities, free from "impurity, were sold at £2 : 10 : 0 per (*Avoirdupois*) pound."

Captain Knott, *Manager of the Mine, MSS.*

"About four miles to the south-east of Callington is a silver mine * * * "situate in a rock of killas or chlorite slate. The vein was first worked for "copper, but native silver and lead-ore were discovered in it. The mine is called "Huel Jewel: the thickness of the vein rarely exceeds three or four inches. In "many of the cavities were found a considerable quantity of capillary native "silver, with galena, red silver-ore, and sulphuret of silver. The ores were ex-"ceedingly rich, and promised * * * an ample recompense to the adventurers."

Rees, *Cyclopædia*, xxxii. (Silver.)

"In Willsworthy mine, on the border of Devon, the *lode* is about twelve inches "wide, bearing N.N.E. & S.S.W., and underlies two feet and a half per fathom "to the south. In the ten fathoms level, a vein of white and amethystine quartz "divided the lode; between this vein of quartz and the lower, or northern wall "of the lode, was found a vein of rich arsenical cobalt ore combined with native "capillary silver, in a ferruginous matrix, from three to six inches wide. The "space between the vein of quartz and the higher, or southern wall of the lode, "was occupied by a vein of rich yellow copper ore, from six to nine inches wide. "The silver continued about two fathoms in length. The copper was not so "soon exhausted. The specimens of native silver from this mine have eclipsed "all that have ever before been found in Cornwall, both in size and beauty."

Carne, *Cornwall Geol. Trans.*, i. p. 124.

Phillips, *Mineralogy* (Third edit.), p. 285. Michell, *Manual of Mineralogy* (Truro, 1825), p. 21. Greg & Lettsom, *Manual of Mineralogy* (London, 1858), p. 240.

Between Marazion and Penzance *West Wheal Darlington* was wrought, in search of copper-ore, to nearly forty fathoms from the surface and some twenty-five below the sea, in closely-jointed, deep blue, homogeneous clay-slate; on a *lode*, which,—bearing 10°-20° N. of E. and S. of W., and composed of quartz, quartzose slate, and iron pyrites,—unexpectedly yielded large masses of native silver, mixed, sometimes, with galena, and, less frequently, with copper pyrites.

The following columns afford particulars of the proceeds:—

Date.	Weight of ore, 20 cwt. to the ton.				Proportion of			Price of ore per ton.			Amount.		
	tons	cwt.	qrs.	lbs.	Silver.	Lead.	Copper.	£	s.	d.	£	s.	d.
1852.													
Nov. 9th	0	14	0	0	0·032100	....	....	256	5	0	179	7	6
"	0	18	3	0	0·008048	....	....	71	12	0	67	2	6
"	1	4	0	0	0·001805	....	....	9	5	0	11	2	0
"	0	9	0	0	0·003825	0·322500	....	33	10	0	15	1	6
1853.													
Jan. 31st	3	1	1	0	0·004957	....	....	29	1	0	88	19	2
"	4	19	1	15	0·001224	....	....	7	12	6	37	17	7
Mar. 29th	1	18	3	20	0·002815	0·630000	....	38	16	8	75	11	10
May 10th	0	4	3	14	0·060282	....	....	523	15	0	127	13	2
"	3	9	2	1	0·007497	....	....	51	2	0	177	12	0
"	1	5	0	16	0·003978	....	....	16	0	0	20	2	3
"	1	18	3	17	0·003672	....	....	25	5	0	49	2	2
"	1	9	1	26	0·002142	....	....	15	10	0	22	16	9
Forward .	21	13	0	25							872	8	5

with the chloride and chloro-bromide of silver; and,

1853.	tons	cwt.	qrs.	lbs.				£	s.	d.	£	s.	d.
Forward.	21	13	0	25	......	......	......	....			872	8	5
July 19th	0	5	2	22	0·076500	....	....	634	15	0	180	15	10
,,	3	7	0	15	0·005141	....	....	36	12	0	123	1	10
,,	2	10	2	20	0·004896	....	....	32	4	0	81	11	10
Aug. 18th	0	11	0	19	0·030294	....	....	305	0	0	170	6	10
,,	1	2	0	21	0·001867	0·572500	....	20	4	0	22	8	1
,,	3	4	0	11	0·002815	....	....	19	12	0	62	16	2
,,	9	2	0	5	0·002509	....	....	13	6	0	121	1	2
,,	4	6	1	24	0·001254	....	....	6	10	0	28	2	3
,,	1	10	2	21	0·000612	....	....	3	0	0	4	12	0
Sept. 28th	0	8	2	11	0·112118	....	....	1075	5	0	462	5	2
,,	2	8	0	11	0·004039	....	....	35	15	0	85	19	6
,,	3	18	3	12	0·001867	....	....	10	15	6	42	9	7
,,	7	9	1	10	0·002867	....	....	19	0	0	141	17	5
,,	3	16	1	5	0·002509	....	....	12	15	0	48	12	8
Nov. 9th	0	9	3	2	0·039351	....	....	372	15	0	182	0	11
,,	11	14	3	0	0·001254	....	....	8	1	6	94	15	7
,,	10	5	3	0	0·001560	....	....	7	18	6	81	10	6
,,	7	5	3	22	0·001060	....	....	5	5	0	38	6	3
,,	2	0	2	0	0·000627	....	....	2	0	0	4	1	0
Dec. 20th	2	0	0	0	0·002172	....	....		—			—	
,,	6	0	0	0	0·001224	....	....		—			—	
,,	10	0	0	0	0·000765	....	....		—			—	
,,	15	0	0	0	0·000612	....	....		—			—	
,,	5	0	0	0	0·000551	....	....		—			—	
,,	2	10	0	0	0·000306	....	....		—			—	
1854.													
Feb. 22nd	2	7	0	25	0·002509	....	....	24	10	0	57	17	0
,,	17	7	0	21	0·001163	....	....	7	5	0	125	17	1
April 11th	5	5	0	0	0·001652	....	....	16	10	10	86	12	6
May 25th	1	13	2	12	0·002540	....	....	18	5	0	30	13	3
,,	7	8	1	6	0·001224	....	....	6	15	0	50	1	0
July 19th	0	16	2	12	0·143820	0·335000	....	65	0	0	53	19	4
,,	0	12	1	18	—	....	....	22	15	0	14	2	4
,,	4	2	1	16	—	....	....	7	16	0	32	2	9
,,	1	17	0	7	—	....	....	4	5	0	7	17	6
Aug. 30th	0	17	3	27	0·000964	0·436250	....	20	2	0	18	1	8
,,	5	18	2	0	0·001224	....	....	12	17	2	75	3	6
,,	2	3	1	14	0·000918	....	0·060000	11	4	8	24	17	3
Nov. 15th	4	1	1	0	0·001102	....	....	6	0	0	24	7	6
,,	2	14	3	0	0·000612	....	....	2	12	4	7	3	4
Dec. 31st	52	4	0	0	0·000306	....	....						
,,	18	19	1	0	0·000409	....	....	1	0	0	150	18	0
,,	79	14	3	0	0·000153	....	....						
1855.													
Feb. 14th	0	0	0	7	—	....	....	5120	0	0	16	0	0
24th	2	3	1	0	0·001316	0·290000	....	12	10	0	27	0	7
,,	1	5	0	0	0·000153	....	0·062500	5	18	10	7	7	6
,,	2	0	3	0	0·001163	....	....		—			—	

	tons	cwt.	qrs.	lbs.		£	s.	d.	
Quantity of ore sold..	309	3	1	1	Highest price of ore ₰ ton,	£5120	0	0	.. £3659 5 1 Value of ore sold.
,, unsold.	42	10	3	0	Lowest ,, ,,	1	0	0	
					Average ,, ,,	11	16	8	

For this account, compiled from the Mine-books, I am indebted to W. J. Rawlings, Esq., *of Hayle.*

more sparingly with vitreous and red silver; but they

Arsenical silver-ore has been discovered in quartz near Camborne; and native silver in copper pyrites at *Crennis*, near St. Austell,—in (*gossan*) quartzose earthy brown iron-ore at the *Fowey Consolidated Mines* near Fowey,—and in galena at *Wheal (Providence) Tremayne* near Hayle; in each of these instances the quantity has been very small.

Michell, *Manual of Mineralogy* (Truro, 1825), p. 21. Garby, *Cornwall Geol. Trans.*, vii. p. 88. Greg & Lettsom, *Manual of Mineralogy* (London, 1858), p. 240.

"Dr. Woodward (vol. ii. page 29) gives a very advantageous character of the "ore found at Guarneck, in the parish of St. Allen near Truro. It was a blue "lead ore, very rich in silver, perhaps beyond any in England besides: * * * "one of the proprietors, and some of the workmen, averred, that a ton of it "yields 140 ounces (0·004284 its weight) of silver.

"The ore which is poor in lead, does sometimes yield silver plentifully."

"Borlase, *Natural History*, pp. 210, 211.

"In the Garres in St. Allen the ore when last wrought was so rich in silver, as "to yield one hundred ounces to one ton of lead" (0·003060 its weight).

Pryce, *Mineralogia Cornubiensis*, p. 58.

"Guarneck near Truro, now called the Garres, was wrought about 1720, when "some of its lead produced" (0·003060 its weight) "one hundred ounces of "silver per ton. In 1814 it was again set at work, and continued two years. "During this period it produced eight hundred tons of silver lead ore, containing "thirteen parts in twenty of lead, and the lead yielding seventy ounces of silver "per ton."

The proportion of lead in the ore was 0·650000 its weight; and
,, silver in the lead ,, 0·002142 ,, .

Carne, *Cornwall Geol. Trans.*, i. p. 120.

Polwhele, *Cornwall*, iv. p. 134. C. S. Gilbert, *Cornwall*, i. p. 259. Rees, *Cyclopædia* (Silver), xxxii. Hitchins & Drew, *Cornwall*, i. p. 624. Phillips, *Mineralogy* (3rd edit), p. 335. Michell, *Manual of Mineralogy*, p. 13.

"Silver united with lead in the state of galena is found in the mine of Huel "Pool."—Klaproth, *Mineralogical Observations on Cornwall*, p. 30.

Berger, *Geological Transactions*, i. p. 171. Lysons, *Cornwall*, p. ccix. C. S. Gilbert, *Cornwall*, i. p. 259.

"Huel Pool near Helston was wrought upwards of two hundred and fifty "years ago, * * * and about eighty years since yielded tolerable profit to the "adventurers. About 1790 it was again set at work and produced lead ore which "yielded from thirty to forty ounces per ton" (0·000918 to 0·001224 its weight) "of silver.—Carne, *Cornwall Geol. Trans.*, i. p 119.

"The galena of Huel Pool yielded sixty ounces" (0·001836 its weight) "of silver per ton."—Phillips, *Mineralogy* (3rd edit.), p. 335.

Michell, *Manual of Mineralogy*, p. 13. De la Beche, *Report on Cornwall, &c.*, p. 611.

are destitute of those still rarer silver-ores afforded by the *lodes* in congenial strata below.

"The mines at Penrose near Helston have been wrought above two hundred "years."—(WOODWARD, II. p. 28.) BORLASE, *Natural History*, pp. 210, 211.

"At Penrose there is a rich bunch of galena which opens up in the surface."

KLAPROTH, *Mineralogical Observations*, p. 30

BERGER, *Geological Transactions*, I. p. 173. POLWHELE, *Cornwall*, IV. p. 134. C. S. GILBERT, *Cornwall*, I. p. 259.

"Huel Rose was wrought nearly at the same time as Huel Pool. Its lead ore "yielded sixty ounces" (0·001836) "of silver per ton."

CARNE, *Cornwall Geol. Trans.*, I. p. 120.

DE LA BECHE, *Report on Cornwall, &c.*, p. 611.

"The ore richest in silver has no more than the appearance of spar, and some- "times common clay. * * * I have seen lead-ore broke in the tenement of "Nanskêg, in Illogan parish, bedded in a yellow clay of the exact colour of sul- "phur, * * * very heavy, and reckoned rich in lead."

BORLASE, *Natural History*, pp. 211, 212.

"In Nanskuke Downs, in a very promising gossan, we discovered * * * very "rich lead of the antimoniated kind. * * * The silver in it was plenty, inso- "much as to render the mineral worth £18 or £20 per ton without any dressing."

PRYCE, *Mineralogia Cornubiensis*, p. 58.

"The lead veins lately discovered by Sir Christopher Hawkins on draining a "marsh in the parish of Newlyn, run nearly east and west. * * * Beside the "lead, and a little quartz, they consist entirely of clay. Those veins are far "richer than any north and south veins in which lead has yet been found. The "lead yields about sixty ounces" (0·001836 its weight) "of silver per ton."

CARNE, *Cornwall Geol. Trans.*, II. p. 114.

"At Huel Rose in Newlyn, during 1822, the sulphuret of lead and silver from the

	Proportion of lead in ore.	Proportion of silver in ore.		lead.
North lode	0·670000	0·001345		0·002010
South lode	0·770000	0·001414	to	0·001836
		0·001532	,,	0·001989

and the lead after it had been refined still contained .. 0·000030 its weight of silver."—MICHELL, *Manual of Mineralogy*, p. 19.

DAVIES GILBERT, *Cornwall*, III. p. 272.

"The lead of Cornwall and Devon is rich in silver, so as to yield on an average "20 to 30 oz." (0·000612 to 0·000918) "per ton."

PATTINSON, *Reports of the British Association*, VII., Notices, p. 51.

"East Huel Rose yielded, in 1852, as much as 2381 tons 3 cwt. of lead-ore, "giving 1607 tons of lead metal, and also 48,000 ounces of silver."

Cornwall, its Mines and Miners, p. 229.

At small depths, therefore, the *lodes* are richest in

Still more recently the produce has been,—

		1856. Proportion of silver in lead-ore.	lead.	1857. Proportion of silver in lead-ore.	lead.
Cornwall.	*South Garras*	0·001351	0·002955	0·001366	0·003360
	Huel Langford	0·001467	0·005080	0·001458	0·002041
	Huel Treweatha	0·000465	0·000830	0·001231	0·002020
	East Huel Falmouth ..	0·001142	0·001714	0·001595	0·001989
	Huel Mary Ann	0·001168	0·001897	0·001125	0·001912
	Huel Trelawny	0·000966	0·001371	0·001028	0·001439
	Budnick Consols	0·000861	0·001387	0·000858	0·001208
	Huel Ludcott	0·000750	0·001132	0·000746	0·001163
	Pentire Glaze	0·000632	0·001114	—	—
	Holmbush............	0·000867	0·001506	0·000671	0·001010
	East Huel Rose	0·000577	0·000918	0·000577	0·000918
	Carn Vivian	0·000408	0·000918	—	—
	Huel Wrey Consols....	0·000646	0·000949	0·000569	0·000918
	Swanpool	0·000444	0·000918	0·000012	0·000025
	Herodsfoot	0·000359	0·000449	0·000653	0·000898
	Cargol	0·000504	0·000826	0·000554	0·000887
	South Cargol	0·000540	0·000887	—	—
	Great Huel Baddern ..	0·000440	0·000661	0·000500	0·000765
	Huel Golden	0·000371	0·000709	—	—
	Penhaldarva	—	—	0·000425	0·000576
	Pennance Stamps	0·000166	0·000490	—	—
	Cubert United	0·000297	0·000410	0·000096	0·000477
	Boiling Well	0·000197	0·000266	0·000301	0·000421
	North Huel Trelawny..	0·000257	0·000539	0·000239	0·000336
	Huel Trehane	0·001199	0·001775	0·000105	0·000214
	Great Hewas	0·000070	0·000122	—	—
	Hender	—	—	0·000066	0·000066

Mr. Hunt, *Memoirs of the Geological Survey of Great Britain*,—Mineral Statistics. 1856, pp. 29, 30; 1857, pp. 31, 32.

In each of Mr. Hunt's groups some mines seem to afford the ores of both lead and silver, whilst others appear to yield lead-ore alone; but whether silver is mentioned only when its proportion is known, or some lead-ore is really unmixed with silver, does not appear.

Silver has been obtained from many other Cornish lead-mines; which have been described by Borlase, *Natural History*, p. 210.— Pryce, *Mineralogia Cornubiensis*, p. 58.—Berger, *Geological Transactions*, i. p. 171.—William Phillips, *Ibid*, ii. pp. 121–5.—Lysons, *Cornwall*, ccix.—Polwhele, *Cornwall*, iv. p. 134.—C. S. Gilbert, *Cornwall*, i. p. 259.—Hitchins & Drew, *Cornwall*, i. p. 624.—Carne, *Cornwall Geol. Trans.*, ii. p. 112.—Michell, *Manual of Mineralogy*, pp. 9, 14.—Dr. Boase, *Cornwall Geol. Trans.*, iv. p. 193.—Davies Gilbert, *Cornwall*, iii. p. 47.—De la Beche, *Survey of Cornwall*, &c., pp. 284, 287, 610–12.—Allen, *History of Liskeard*, pp. 421–432. See also *Cornwall Geol. Trans.*, v. pp. 140, 193, 255, 268; and *Report of the Royal Institution of Cornwall* (1851), pp. 38–43.

At Trebisken-green a *lode* oblique in direction to the large iron-vein, so well known in the same neighbourhood (*Cornwall Geol. Trans.* v. p. 108.), affords

amalgamable *(metales calidos)*, — but at greater, in smelting ores *(metales frios)*.

At Pajonales, an adjoining mountain west of Chañarcillo, the shallow parts of many *lodes* afforded much silver-ore; * but at greater depths it was replaced by the ores of nickel and cobalt.

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irregular masses *(bunches)* of rich ore. This, for the most part, is galena; which sometimes contains no more than 0·000153, but in some cases it has yielded as much as 0·091922,—0·104040,—and even 0·122584 its weight of silver. Portions of the *lode* however have produced 0·107100 their weight of metal, from vitreous silver-ore and native silver, unmixed with lead.

The ore sold from Trebisken-green mine has been

Date.	Weight of ore, 20 cwt. to the ton. tons	cwt.	qrs.	lbs.	Purchasers.	Proportion of lead.	Price of ore per ton. £	s.	d.	Amount. £	s.	d.
1859.												
Sept. 14th	1	14	2	0	Rob. Michell & Son.	0·750000	95	10	6	164	15	6
26th	0	2	0	0	Ditto ..	0·450000	74	3	4	7	8	4
1860.												
Mar. 13th	0	1	3	16	Trustees of Treffry Estate	0·750000	435	10	6	41	4	4
„	0	14	3	19	Ditto ..	0·650000	135	0	0	100	14	1
„	0	4	3	11	Ditto ..	(Slimes)	7	10	0	1	16	4
Aug. 14th	1	9	0	12	Rob. Michell & Son.	0·650000	333	7	6	485	3	6
„	2	19	0	1	Ditto ..	0·612500	97	0	0	286	3	10
	7	6	1	3						£1087	5	11

Assays show the silver contained to have been (3868 troy ounces per ton)—
0·016189 the weight of ore,
or 0·024590 „ lead. *Account Books of the Mine.*

"In the island of Sark no silver ores, except a few crystals of ruby silver, "occur uncombined with lead in the western part of the Sark mine; but east-"ward the lode contained rich deposits of silver ores without any lead. The "muriate of silver was imbedded in gossan, and mixed with the blue and green "carbonates of copper near the surface; but at, and for thirty fathoms below, "the adit (sea level) it was replaced by black sulphurets of silver and copper, "mixed with disintegrated iron pyrites; and still deeper the sulphuret of silver "was found combined with the sulphurets of copper and antimony. In the "deeper levels west the lode afforded sulphato-tricarbonate of lead, sulphuret of "lead, super-sulphuret of lead, black sulphuret of lead (rich in silver), antimon-"iferous galena, and granular galena which contained,—

Lead in the ore.		Silver in the ore.		Silver in the lead.
0·200000 to 0·850000	....	0·000096 to 0·000384	—	0·000019 to 0·000326."

PRINCE, *Cornwall Geol. Trans.*, VI. 102.

* M. Domeyko, *Annales des Mines*, 4me Série, IX. p. 434.

It has been already said * that the *lodes*—passing uninterruptedly downward, through three strata of limestone (*a. c. e.*) alternating with two of greenstone (*b. d.*), and partaking in turn the nature of every rock they traverse—are productive in the limestone alone. Much smaller than similar deposits of tin, lead, and copper elsewhere,† the masses—(in Cornish mining language rather *bunches* than *courses* ‡)—of rich silver-ore they afford,—as well as the congenial earthy matrix surrounding them, which is severed merely by unkindly hornblendic ingredients in the greenstones,—maintain —in obedience, perhaps, to a common influence—one uniform *shoot* § or inclination throughout the three limestones *(Pl. II.)*. This slope—subordinate to that of the granitic formation between Chañarcillo and Pabellon on the north ||—is more rapid than that of either the strata or their several beds; and, like it, is towards the south-west.

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* *Ante*, pp. 69, 70.

† Borlase, *Natural History*, Pl. XVIII. Pryce, *Mineralogia Cornub.*, Pl. IV. Héron de Villefosse, *La Richesse Minéral*, Pl. V. VI. VII. XII. XIII. XIV. XV. XVI. XVIII. XIX. XX. Thomson, *Travels in Sweden*, Pl. X. Williams, *Geological Transactions*, IV. Pl. 7, fig. 3. Weaver, *Geological Transactions*, V. Pl. 12. Clarke, *Travels* (Edit. 1824), X. p. 521. Burr, *Practical Geology*, Pl. VIII. IX. De la Beche, *Report on Cornwall, &c.*, Pl. VIII. IX. Henwood, *Cornwall Geol. Trans.*, V. Pl. I. fig. 9;—Pl. IV. fig. 4. Foster & Whitney, *Report on the Copper-Lands of Lake Superior*, Pl. VII. Whitney, *Metallic Wealth of the United States*, Pl. I. II. III. Pernollet, *Annales des Mines*, 4me Série, X. Pl. 5, fig. 9;—Pl. 6, fig. 7, 10, 15, 17. *Encyclopædia Britannica* (8th Edit.), XV. p. 224, fig. 3.

‡ " When the *lode* consists either entirely, or for the most part, of ore, it is " provincially called *a course of ore;* and, if the metallic substances appear in " short and unconnected masses, they are designated *bunches of ore.*"

Cornwall Geol. Trans. V. p. 210.

§ *Cornwall Geol. Trans.*, V. pp. 41, 54, 87*, 129, 193;—VI. p. 146.

|| *Annales des Mines*, 4me Série, IX. Pl. IV.

When the *lodes* of Chañarcillo—whilst they traverse the first and second limestones, — are viewed either longitudinally or transversely, the rich portions of some confront the poor parts of others; although meridional lines,—to which their directions are oblique,—intersect the productive parts of all.*

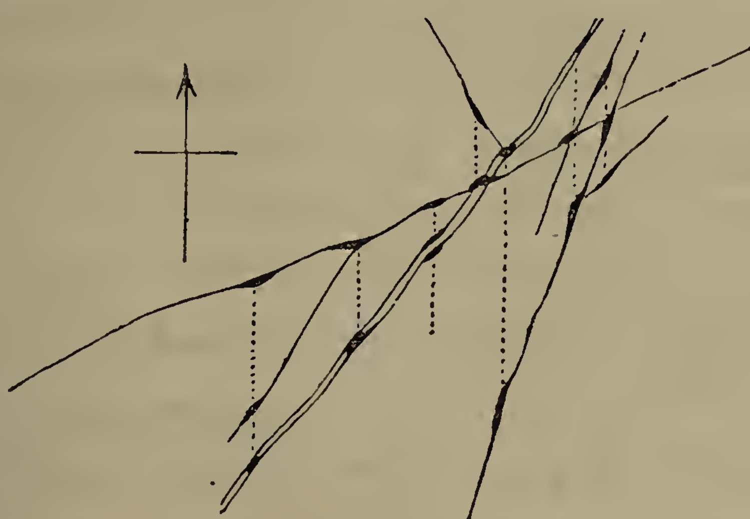

Fig. 9. *Plan.*

The extent and (approximate) produce of the principal mines wrought in Chañarcillo during the five-and-twenty years ending with 1856, have been,†—

Mine.	Extent, fathoms.		Formation.	Produce (approximately).
Manto de Ossa	94 × 48	......	*Manto* .... *Colorada lode* ...... *Waring's lode* ...	£400,000
Valenciana	47 × 43	......	*Manto* .... *Colorada lode* .. ... *Waring's lode* ...	300,000
			Forward	£700,000

* Carne, *Cornwall Geol. Trans.*, III. p. 78. See also *Ibid*, V. pp. 87*, 215, 233; and *Ante*, p. 16.

† Edwin Price Waring, Esq., of Neath, Manager of *Colorada* & *Descmpeño*, MSS.

Mine.	Extent, fathoms.		Formation.	Produce (approximately).
		Forward	....	£700,000
Esperanza	141 × 39	......	*Colorada lode* ...... *Waring's lode* ... *Candelaria lode* ... *Bolaco lode*	200,000
Bolaco	94 × 48	......		
Colorada	85 × 46	......	*Colorada lode* ... *Waring's lode* ... *Candelaria lode* ...	600,000
Desempeño	57 × 64	......	*Colorada lode* ...... *Waring's lode* ...	120,000
San Francisquito ...	48 × 58	......	*Ditto*	200,000
Bocona	29 × 39	......	*Ditto*	60,000
San José	65 × 51	......	*Ditto*	700,000
San Francisco viejo.	94 × 48	......	*Ditto*	800,000
San Francisco nuevo.	85 × 48			
Delirio	88 × 75	......	*Ditto*	300,000
Constancia	93 × 42	......	*Ditto*	160,000
San Blas	93 × 42	......	*Ditto*	100,000
Descubridora	— × —	......	*Descubridora lode.*	2,000,000
Mina de Carvallo ...	— × —	......	*Guias de Carvallo.*	200,000
				£6,140,000

Beside these there are several smaller mines of which it is not easy to ascertain the produce.

(D) (1.) Several *cross-veins* coincide in direction with two series of the joints;* and traverse, like them, both the rocks and *lodes* of Chañarcillo. They are,

Mine.	Cross-vein.		Direction.	Dip.
Manto de Ossa.	*Great Flucan*		31° E. of S. & W. of N. ..	N.E.
Colorada	*Cross-vein*		25° S. of E. & N. of W. ..	N.
San José	*Northern Flucan*	Eastward	30° E. of S. & W. of N. ..	N.E.
		Westward	5° W. of S. & E. of N. ..	E.
	Southern Flucan		30° E. of S. & W. of N. ..	N.E.
San Francisco viejo	*Flucan*		28° E. of S. & W. of N. ..	N.E.

* *Ante*, p. 74.

The *cross-vein,* intersected at a depth of fifty-five fathoms in *Colorada,* extends, however, neither upward to the surface, nor downward to the first hornblendic formation.*

(2.) Their inclination towards the north and east is opposite, as well to the nearest slope of granite,† as to the strata ‡ and *ore-shoots* in the *lodes,*§ all which dip to the south and west.

(3.) The *Great Flucan* is, at the *Manto de Ossa,* as much as eleven fathoms, whilst the *cross-vein* in *Colorada* is no more than a foot, in width. The other *flucans,*—of intermediate dimensions,—usually average from ten to twelve feet.

(4.) The *cross-veins,* like the *lodes,* resemble the rocks they traverse, in mineral composition, and are calcareous in the limestone, but hornblendic in the greenstone series. Generally much softer than the strata, and sometimes composed almost wholly of clay, they are divided by many longitudinal joints,‖ of which the usually glossy sides are often deeply though irregularly furrowed, with highly inclined undulating striæ.¶ Their stony ingredients are however more crystalline than those of the *lodes.*

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* *Cornwall Geol. Trans.,* v. p. 381.

† *Cornwall Geol. Trans.,* v. p. 277. *Ante,* pp. 71–74.

‡ *Ante,* pp. 71–73. § *Ibid,* p. 123. *Cornwall Geol. Trans.,* v. pp. 259-261.

‖ " One of the most remarkable features in the structure of *cross-veins* is the " prevalence of joints. Owing to this prevalence the *cross-veins* have generally " more distinctly marked *walls* or boundaries than the *lodes.* The same structure " is, moreover, so common in the vicinity of *cross-veins,* that the rock on both " sides often, fo rseveral fathoms, consists as it were of alternate veins of quartz " and of the adjoining stratum.—*Cornwall Geol. Trans.,* v. p. 260.

¶ *Ante,* p. 13.

Near the *Manto de Ossa* many small drusy hollows in the *Great Flucan* unite to form an irregular cavern of more than forty-five fathoms long.*

The strata maintain the same respective levels on opposite sides as well of every *lode* † as of every *cross-vein* in Chañarcillo, except at *San Francisco viejo;* but there,—as already mentioned,‡—each formation is on the south-west *(foot-wall)*, about twenty-one fathoms higher than its counterpart on the *(hanging-wall)* north-eastern side of the *flucan.*

(*a.*) Some of the *lodes* intersect others;—but, with one exception only,—they are all intersected by the *cross-veins.*

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* *Ante*, p. 89. † *Ibid*, p. 87. § *Ibid*, p. 71.

Intersecting *veins*.	Intersected *veins*.	Angle they include.	Results.
Colorada and *Waring lodes* ..	*Candelaria lode*	32°	*Candelaria lode heaved* 13·6 fms. L. G. A.
Descubridora lode	„	52°	„ „ 5·5 „ L. G. A.
Loreto „	„	32°	The *lodes* unite.
Candelaria „	*Guias de Descubridora* ..	52°	The *Guias* are simply intersected.
„ „	*Guanaca lode*	25°	*Guanaca lode heaved* 20·2 fms. R. G. A.
Great flucan	„	76°	„ „ 93·6 „ L. G. A.
„	*Candelaria lode*	79°	*Candelaria lode* „ 81·6 „ L. S. A.
„	*Descubridora* „	49°	*Descubridora lode* „ 98·2 „ L. G. A.
„	*Waring's* „	69°	*Waring's lode* „ 97·5 „ L. G. A.
„	*Colorada* „	69°	*Colorada lode* „ 97·7 „ L. G. A.
Colorada cross-vein	„ „	77°	*Cross-vein* simply intersected.
San José. Northern flucan ..	*Waring's* „	68°	*Waring's lode heaved* 3·5 „ L. G. A.
„ „ ..	*Colorada* „	68°	*Colorada lode* „ 3·5 „ L. G. A.
„ „ ..	*Loreto* „	65°	*Loreto lode* „ 9·2 „ L. G. A.
„ *Southern flucan* ..	*Waring's* „	68°	*Waring's lode* „ 8·5 „ L. G. A.
„ „ ..	*Colorada* „	68°	*Colorada lode* „ 8·5 „ L. G. A.
„ „ ..	*Loreto* „	65°	*Loreto lode* „ 7·7 „ L. G. A.
San Francisco viejo. Flucan.	*Waring's* „	66°	*Waring's lode* „ 17·0 „ L. G. A.
„ „ ..	*Colorada* „	66°	*Colorada lode* „ 17·0 „ L. G. A.
„ „ ..	*Loreto* „	63°	*Loreto lode* „ 16·5 „ L. G. A.

(1.) Chañarcillo thus presents five contacts of different *lodes*;*—

in one of which two *lodes* unite;

" a second, " one *lode* simply intersects another;—

" a third " one " *heaves* the other to the (R.) right-hand;— } but all of them towards the (G. A.) greater angle.

and the remaining two *lodes heave* other two to the (L.) left-hand;— } but all of them towards the (G. A.) greater angle.

(2.) It exhibits also fourteen intersections of *lodes* by *cross-veins*,†—

at each of which the *lode* is *heaved*;

all these *heaves* are to the .... (L.) left-hand;

but thirteen of them are towards the... (G. A.) greater angle;

whilst one only is " ... (S. A.) smaller " .

But though the *heaves* of different *lodes* by the same *cross-vein* are not, in all cases, towards like angles; they are—in Chañarcillo at least—always to the same hand.‡

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* In Cornwall and Devon twenty intersections of *lodes* by other *lodes* of similar composition, exhibit—

six (30 per cent.) simple intersections,—
nine (45 ") *heaves* to the right-hand, and—
five (25 ") " " left-hand:
nine (45 ") " towards the (S. A.) smaller angle, and—
five (25 ") " " (G. A.) greater angle.

Cornwall Geol. Trans., v. p. 289.

† Of 233 intersected *lodes* in Cornwall and Devon,—

108 are traversed by *(cross-courses)* quartzose, and 125 by *(flucans)* clayey *cross-veins*.

	by *cross-courses*,	by *flucans*.
The *lodes* intersected but not *heaved* are	31 or 28·7 per cent.,	22 or 17·6 per cent.
" *heaved* to the (R.) right-hand,	48 " 44·4 "	69 " 55·2 "
" " (L.) left-hand,	29 " 26·9 "	34 " 27·2 "
" *heaved* towards the (G. A.)— greater angle,	64 " 59·3 "	88 " 70·4 "
" " (S. A.)— smaller angle,	13 " 12·0 "	15 " 12·0 " .

Cornwall Geol. Trans., v. pp. 291–2.

‡ "As more than 97 per cent. of the *lodes* traversed by *cross-veins* in Cornwall "and Devon are either *heaved* in the same direction, or are simply intersected,—

Between the extent to which the *lodes* are *heaved* by *cross-veins,* and the magnitude of the angles included at their contact, no relation can be traced in Chañarcillo; * where *heaves,* differing widely in extent, attend intersections at nearly similar angles.

The *cross-vein* by which the *lodes* are *heaved* furthest is however the largest,† as well as the most highly inclined in the district.

(3.) The *Colorada lode* intersects, but does not *heave,* a small *cross-vein;* ‡ which is traced, either vertically or horizontally,§ but a very short distance.

(4.) Each of the five strata on one side corresponds exactly both in thickness, and — with but a single

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"whilst less than 3 per cent. are *heaved* in opposite directions, it may be assumed, "generally, that *the heaves of different lodes by the same cross-vein,* are in the "same direction.—*Cornwall Geol. Trans.*, v. p. 324.

*In Cornwall and Devon the relations between the angles included and the results of the intersections are,—

Angle included	Proportion of intersections unattended by *heaves.*	Proportion of *heaves.*	Average distance of *heave.*
0°—10°	—	—	—
10°—20°	0·4 per cent.	0·4 per cent.	1·00 fms.
20°—30°	0·8 ,,	3·1 ,,	2·55 ,,
30°—40°	0·8 ,,	3·1 ,,	4·03 ,,
40°—50°	0·4 ,,	6·7 ,,	5·40 ,,
50°—60°	2·6 ,,	5·8 ,,	3·23 ,,
60°—70°	4·8 ,,	11·9 ,,	2·06 ,,
70°—80°	4·3 ,,	20·7 ,,	2·65 ,,
80°—90°	8·7 ,,	25·5 ,,	2·71 ,,

Cornwall Geol. Trans., v. p. 301.

"† In Cornwall and Devon the average distance of the *heaves* by *cross-veins*—
"less than one foot wide, is .... 2·08 fms.,
"more than one foot wide, ,, ... 3·83 ,, ."

Cornwall Geol. Trans., v. p. 298.

‡ *Ante,* p. 12.

§ "In Cornwall and Devon there are *cross-veins* * * * which appear only at "considerable depths; * * * whilst others extend but short distances horizon- "tally."—*Cornwall Geol. Trans.*. v. pp. 311, 312.

exception*—in level, with its counterpart on the other side of every *lode*† and *cross-vein*‡ in Chañarcillo. These conditions are as incompatible with either a vertical or an oblique movement of the rocks on one side or other of the veins; as they are with motion in any direction, save one parallel to the normal position of the upper and lower faces of each stratum § in the series.‖ Nor is it easy,—if indeed it be possible,—to reconcile even this¶ with the unequal displacements *(heaves)* of different *lodes* by the same *cross-vein*.**

(—*a*.) In the exceptional case at *San Francisco viejo* the strata,—horizontal on both sides of the *flucan*,—are twenty-one fathoms lower in its north-eastern or upper side *(hanging-wall)*, than their respective counterparts in its south-western or lower side *(foot-wall)*†† *(Section, Pl. II.)*; whilst the *Waring*, *Colorada*, and *Loreto* or *Dolores Primera lodes*,—all dipping 64°—78° N.W., are *heaved* by the same *flucan*,—the first two 17·0 the last 16·5 fathoms,—towards the (L. G. A.) left-hand and the greater angle *(Plan, Pl. I.)*.

(—*b*.) The coincidence of alternating strata which confront,—each its counterpart—on opposite sides of a *(cross-vein) flucan*, can be deranged by no movement, of one side or other, parallel to their upper and lower faces. But every vein—either vertically or obliquely,

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* *Ante*, pp. 71, 72, 125. † *Ante*, p. 87. ‡ *Ante*, p. 125.

§ If the upper and lower planes are not absolutely parallel, any movement coincident with one of them must necessarily displace the other.

‖ *Ante*, p. 87. ¶ *Ante*, p. 127. *Table III. Pl. I.*

** *Cornwall Geol. Trans.*, v. pp. 320—322.

†† Professor Phillips, *Illustrations of the Geology of Yorkshire*, Part II., p. iii. Pl. XXIV. fig. 16. *Ante*, p. 72, Note.

—traversing strata so moved, must of necessity be displaced *(heaved)* an equal distance in the same direction.*

(—*c.*) A vertical elevation of twenty-one fathoms on the south-western or lower side *(foot wall)* of the *flucan* at *San Francisco viejo* would have produced the difference observed in the level of identical strata on its opposite sides; but such a movement must have necessitated *heaves* of all *lodes* dipping—as these *lodes* dip—64°-78° N.W.—

	from 9·6	to 5·0	fms.	towards the right-hand;
whereas the actual *heaves* are	16·5	„ 17·0	„	„ left- „ .†

Hence, neither a horizontal (—*b.*) nor a vertical (—*c.*) movement resolves,—even approximately,—this inseparably connected group of phenomena.

(—*d.*) An elevation on one side produces the same displacement as a depression on the other, when opposite sides *(walls)* of the *(cross-vein) flucan* are moved equal distances at similar angles, in contrary directions.‡ The following columns therefore represent dynamical equivalents:—

Side moved.	*Direction of movement.*
South-western or lower side *(foot wall)*	*Upheaved* towards the south-east.
North-eastern or upper side *(hanging-wall)*...	Depressed towards the north-west.

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* *Proceedings of the Geological Society of London* (1832), I. p. 406. *Cornwall Geol. Trans.*, v. pp. 347, 355.

† *Proceedings of the Geological Society of London* (1832), I. p. 406. *Edinburgh New Phil. Journal*, XXII., p. 161. *Reports of the British Association*, VI. Part II. p. 74. *Cornwall Geol. Trans.*, v. pp. 347, 356. Mr. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836), p. 123. Sir Henry T. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, pp. 298-300.

‡ *Cornwall Geol. Trans.*, v. pp. 346, 348.

When several planes, inclined at different angles, are intersected and displaced on another plane oblique to them all, the extent of displacement measured on the line of movement is in every case the same; but at right angles to the dip of each vein so dislocated it is proportional to the angle included between the dislocated and the dislocating planes.

The following theoretical enquiries embrace the direction, inclination, and extent of the motions,* adequate to produce, under different circumstances, some of the displacements observed in the strata and *lodes* of Chañarcillo.

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* *Cornwall Geol. Trans.*, v. p. 366.

Formation.	Conditions necessary to the displacements.					Extent of displacements.	
	Dip or position observed.	Dip required by theory to produce observed displacements.	Particulars of requisite movement. Direction.	Inclination.	Extent fms.	Calculated. fms.	Observed. fms.
Strata	Horizontal ..	....	28° E. of S. or W. of N.	37° 45′	34·3	21·0 Vertical.	21·0 Vertical.
Waring & Colorada lodes .	Dip N.W. 64°	....	”	37° 45′	34·3	17·0 Horizontal, L. G. A.	17·0 Horizontal, L. G. A.
Loreto lode	Dip N.W. 64°	....	”	37° 45′	34·3	17·0 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.
” ”	....	Dip N.W. 62° 45′	”	37° 45′	34·3	16·5 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.
Strata	Horizontal ..	....	28° E. of S. or W. of N.	38° 20′	33·8	21·0 Vertical.	21·0 Vertical.
Waring & Colorada lodes .	Dip N.W. 64°	....	”	38° 20′	33·8	16·5 Horizontal, L. G. A.	17·0 Horizontal, L. G. A.
Loreto lode	Dip N.W. 64°	....	”	38° 20′	33·8	16·5 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.
Strata	Horizontal ..	....	28° E. of S. or W. of N.	43° 48′	29·8	21·0 Vertical.	21·0 Vertical.
Waring & Colorada lodes .	Dip N.W. 78°	....	”	43° 48′	29·8	17·0 Horizontal, L. G. A.	17·0 Horizontal, L. G. A.
Loreto lode, ...	Dip N.W. 78°	....	”	43° 48′	29·8	17·0 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.
” ”	....	Dip N.W. 76° 45′	”	43° 48′	29·8	16·5 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.
Strata	Horizontal ..	....	28° E. of S. or N. of W.	44° 30′	29·5	21·0 Vertical.	21·0 Vertical.
Waring & Colorada lodes .	Dip N.W. 78°	....	”	44° 30′	29·5	16·5 Horizontal, L. G. A.	17·0 Horizontal, L. G. A.
Loreto lode	Dip N.W. 78°	....	”	44° 30′	29·5	16·5 Horizontal, L. G. A.	16·5 Horizontal, L. G. A.

This comparison of theory with fact shows that the single rectilinear movement which reconciles these displacements of the strata with those of the *Waring* and *Colorada lodes,* whilst all retain their normal inclinations, is incompatible with both the dip and dislocation of the *Loreto* or *Dolores Primera lode.* On the other hand a uniform motion sufficient for the conditions of the strata and the *Loreto lode* is inconsistent with those of the *Waring* and *Colorada lodes.**

The differences depend neither on minor fractures nor on unequal movements of ruptured strata; for of such there is no trace.†

If however the *Loreto lode* had inclined but a little less than the *Waring* and *Colorada lodes,* the very same motion which could displace *(heave)* them seventeen fathoms horizontally, and at the same time elevate the strata twenty-one fathoms vertically, would also have *heaved* it sixteen fathoms and a half.

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* "In Cornwall and Devon, amongst the recorded examples of several *lodes* " intersected by the same *cross-vein,* there is not an instance in which motion in " one direction and of the same extent will restore the continuity of every *lode* so " intersected. * * * * Any such uniform motion will, in fact, produce in their " relative positions on opposite sides of the *cross-vein* greater discordances than " those which at present subsist."—*Cornwall Geological Trans.,* v. pp. 370, 380. *Edinburgh New Philosophical Journal,* XXII. p. 163.

† "If we suppose it possible for the rocks to have been so broken that each *lode* " was contained in a different fragment, and that these minute masses had an " independent motion, in any direction and to any extent required; although such " movements might, within certain limits, have afforded any desired results; yet " the motions in different directions necessary to the production of the observed " phenomena, in different portions, would often have required that the rocks " should, in some spots, have suffered much compression, whilst large vacuities " must have been left in others. Had such convulsions ever taken place, traces " of them must have been conspicuous;—but, in fact, nothing of the kind has " been detected,—even in a single instance."—*Cornwall Geol. Trans.,* v. p. 383. *Edinburgh New Phil. Journal,* XXII. (1837) p. 162.

But such a constant difference in dip,—though of one degree and a quarter only,—would have made this productive *lode* the flattest in Chañarcillo; which is certainly not the case.

Whether these discrepant displacements *(heaves)* of neighbouring *lodes* result from irregularities of outline in those parts which,—touching opposite faces *(walls)* of the same *(cross-vein) flucan* at different depths,—would coincide if they were confronted; or whether the separated portions of identical *lodes* have here,—as in Cornwall and Devon,—unlike configurations on contrary sides of the dividing *(cross-vein) flucan;* the data I possess are insufficient to determine.*

The conditions here assumed suit rigid masses only, and are altogether inapplicable to matter in a plastic, viscous, or semi-fluid state.

Although the sea is of much larger area than the

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* "If those portions of the same *lodes* on opposite sides of the *cross-veins* "which now divide them, had been originally connected and continuous, and "were subsequently separated by a transverse fracture accompanied by an ele- "vation or a depression of one of the severed portions, on delineating the line "of dip of both these segments where they touch the *cross-veins,* we should "expect to find them presenting a perfectly or nearly similar outline; although "the direction of any movement they had undergone might not allow the cor- "responding parts to be found at the same levels. *Pl. XII., Fig.* 15, 16, 17, "18, 19, 20, present these comparisons; and it will be difficult, if not impossible, "to imagine that lines so utterly dissimilar, could ever have been united and "continuous at all parts of their descent, and fractured after they had become "perfectly hardened."—*Cornwall Geol. Trans.*, v. pp. 378–9.

land,* water can neither be a principal constituent of the globe, which—of greater specific gravity than any known rock—has a mean density variously calculated at 4·5—6·5; † nor can it penetrate far into the crust, for at a depth comparatively small‡ it can exist only in the state of vapour.

Water infiltrating from above becomes gradually warmed by the strata it traverses; until, at length vapourized, the descending column is balanced. The unequal temperatures prevailing at different depths necessitate a constant interchange of its particles. Further infiltrations must mix with ascending currents specifically lighter and warmer; and—consequently will again reach the surface—at a temperature higher than that of the rocks through which they issue.§ This equilibrium between the descending water and

* "The area of the solid land bears to that of the sea the proportion of 100 to 284;
"according to Rigaud (*Camb. Phil. Trans.*, vi. (1837) p. 297, „ 100 „ 270;
"but according to other authorities, the proportion is .... 100 „ 284."
Humboldt, *Edinburgh New Philosophical Journal*, xxxix. (1845) p. 108.
See also Malte-Brun & Balbi, *Universal Geography* (London, 1851), p. 57; *Encyclopædia Britannica* (8th Edit. 1856), x. p. 483.

† Maskelyne, *Philosophical Transactions*, lxv. (1775), p. 532. Hutton, *Ibid*, lxviii. (1778) p. 782; cxi. (1821) p. 283. Cavendish, *Ibid*, lxxxviii. (1798) p. 520. Playfair, *Ibid*, ci. (1811) p. 376. De Zach, *L'attraction des montagnes et ses effects sur les fils à plomb ou sur le niveau des instruments d'astronomie* (Avignon, 1814), i. p. 351. Carlini, *Opérations Géodesiques et Astronomiques pour la mesure d'un arc du Parallèle Moyen exécuteés en Piémont et en Savoiè par une Commission d'officiers Piémontais et Austrichiens, en* 1821-22-23 (4º Milan, 1825). Reich, *Versuche über die mittlere Dichtigkeit der Erde* (8vo. Freiberg, 1838), p. 43. Baily, *Memoirs of the Astronomical Society*, xiv. pp. 90, 247. Airy, *Philosophical Transactions*, cxlvi. (1856) p. 343. James, *Ibid*, p. 603.

‡ Babbage, *Ninth Bridgewater Treatise*, pp. 182, 198. William Hopkins, *Phil. Transactions*, cxxxii. (1842) p. 43; cxlvii (1857) p. 805. Hennessey, *Ibid*, cxli. (1851) p. 495. Professor Phillips, *Quarterly Journal of the Geological Society*, xv. (1859) pp. xlv.-l.

§ "Water which descends to the volcanic focus is there converted into steam,

the vapour beneath it, must, of course, occur at depths varying with the quantities and temperatures of the water infiltrating.

Much of this infiltration is from rivers, lakes, and the sea, but the greater part is supplied by rain; which,—however abundant in a well-wooded country, —diminishes as the forests are felled, and sometimes ceases almost entirely when they are destroyed. The surface, thus increasingly exposed to evaporative influences,* becomes more and more dry; the springs

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"which, rising through fissures into higher regions, meets with atmospheric "waters which it warms, and with them returns to the surface."

BISCHOFF, *Edinburgh New Philosophical Journal*, XXVI. (1839) p. 50.

"The various ramifications of the great adit in the Gwennap mining district "have an aggregate extent of between thirty and forty miles. It drains a tract "of about 5,500 acres in area and discharges nearly 1,600 cubic feet of water "per minute. Rather less than one-half of this stream is collected at the adit, "which is from 25 to 30 fathoms deep; the remainder is pumped up from a mean "depth of about 190 fathoms. Its temperature varies between 60·5° and 68°; "and is on an average more than 12° above the mean of the climate."

Cornwall Geol. Trans., V. p. 411.

* "The metalliferous mountain of Marmato in the province of Popayan in "New Granada, is situate in the midst of immense forests. The stream by "which the stampers are worked is formed by the union of many small brooks. "* * * The whole environs of the establishment are thickly studded with wood. "In 1826, when I first visited these mines, Marmato consisted of some miserable "huts inhabited by a few negro slaves. When I quitted Marmato in 1830, it "exhibited the most exhilarating appearance. There were now great work- "shops, a foundery for gold, and powerful machines for the reduction of this "precious metal. All this implies that the wood had been extensively cut down "for the manufacture of the machines, the construction of the buildings, and "the preparing of charcoal. * * * The clearing had been going on for scarcely "two years, when it was noticed that the quantity of water, which was required "for the machines, was sensibly diminished. The volume of water is in fact "measured by the work which the machines perform; and trials by guaging at "different times have likewise proved the diminution of the water."

The town of New Valencia in Venezuela was, according to Oviedo (*Historia de la Provincia de Venezuela*, 1723) in 1555, half a league from the lake of Tacarigua; which is fed by rivulets rising in the surrounding mountains; but its waters have no outlet. As the population increased, and the neighbouring

dwindle, and at length—no longer perennial—appear only at intervals after occasional showers.

The reciprocal relations of vegetation and water, are perhaps, nowhere more conspicuous than in the valley

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lands were cleared and cultivated, streams, which had previously fed the lake, were intercepted by artificial channels for irrigation. Their sources, at length, occasionally failed, their beds were sometimes dry for half the year; and the lake—no longer replenished as it had been—subsided so far that the width of the fertile interval between it and the town has increased to a league. Ancient shoals, now uncovered, appeared as islands; the site of a fort which had in 1740 been an island, became a peninsula; and the inhabitants were at once threatened with a scarcity of both wood and water. In 1822 I visited the district; but Venezuela was no longer subject to Spain. The smiling valley of Aragua had been the arena of most bloody contests; war and death had desolated those happy scenes, and greatly thinned the population. Its wide spreading cultivation was neglected; and forest trees, of rapid growth within the tropics, had in great measure resumed their dominion over that region which its inhabitants, after a century of constant and painful labour, had reclaimed. When clearing was no longer continued, and lands once cultivated had again become part of the forest, the streams reappeared, and, as before, found their way to the lake, which once more overflowed a part of the cultivated plain, submerged the islands, and threatened soon to sever the fort from the main land.

In the island of Ascension a beautiful spring issued from the foot of a mountain which was originally wooded. After a while the forests were felled and the mountain was cleared; when the spring becoming gradually less copious, at length failed. The disappearance of the spring was attributed to the clearing. The mountain was again planted, and after a few years the spring reappeared, became gradually larger, and finally was as copious as ever.

Boussingault (abridged), *Edinburgh New Phil. Journal*, xxiv. (1838) pp. 89-91, 102-3.

The ancient mining laws of Brazil strictly enjoin the careful preservation of forests at the sources of streams.

" Os roçeiros não possão rossar de novo nas cabeceiras dos corregos de pouca
" agoa de que se uza para serviços minerâes, e devão conservar o mato em dis-
" tancia de quinhentos palmas para evitar o damno da falta de agoa que por esta
" causa se experimenta."

Regimento dos Superintendentes, Guardas-Mores, e Officiaes deputados para os Minas do Ouro. Bando, ou Additamento ao Regimento Mineral, 13 de Maio, 1736.

Eschwege, *Pluto Brasiliensis* (Berlin, 1833), p. 145.

The Meuse has varied in volume much more frequently, and has fallen far lower, since the forests near its sources have been destroyed, than formerly."

Professor Borgnet (M. Pimpurniaux), *Guide du Voyageur en Ardenne*, p. 164.

of Copiapò; where, more than two centuries ago, a pleasant river flowed to the ocean through corn fields surpassingly fertile, and orchards rich in the fruits of every clime.* Of its condition during a long period subsequently we have no record; but about forty years since great part of the same tract presented a surface of shingle, pebbles, gravel, and sand, covered with shells near the coast, and everywhere, more or less incrusted with salts of soda and magnesia; through which, for more than thirty miles, a scanty rivulet, thinly fringed with dwarf willows, wound its way to the sea.† Further up the valley, however, trees still

* "The valley of Copiapò is the first of the inhabited valleys of Chile. * * * "The land is of itself very fruitful, and is made more so by a pleasant river, "which runs about twenty leagues in it before it empties itself into the sea, in "a bay which makes its harbour. Here grow all sorts of the natural fruits and "grains of the country and of Europe; the maize yields above three hundred "for one, and the ears of it are almost half a yard long."

Historical relation of the Kingdom of Chile; by ALONSO DE OVALLE *of the Company of Jesus, a native of St. Jago of Chile* (Rome, 1649). PINKERTON, *Voyages and Travels*, XIV. p. 168.

† "On the 23rd of November, 1821, we set off from the coast for Copiapò. " * * * The first part of the road lay along a level hard surface chiefly of rock, "at some places covered with a thin soil. We then entered a broad valley, the "sides of which were formed entirely of water-worn stones and gravel, covered "by a stratum or crust, several yards thick, of a rock composed entirely of "broken shells, stretching, as far as we could discover, over the whole country "bordering on the sea. The valley was three or four miles across, and bore "every appearance of having been, at some former period, the channel of a "mighty river, though now shrunk into a scanty rivulet, flowing almost unseen "amongst dwarf willows, stunted shrubs, and long rank grass. The soil was "completely covered, at every part of the valley, by a layer of salt, several inches "thick, which has since been ascertained by analysis to be sulphate of soda, or "Glauber's salts. It lay like snow on the ground * * *; the dust thrown up "by the horses' feet almost choked us, and the day being dreadfully hot, made "our thirst excessive, when we hailed with delight the sight of a stream; but, "alas! the water was as salt as brine."—HALL, *Journal written on the Coasts of Chili, Peru, and Mexico, in the years* 1820,-21,-and 22, II. p. 21.

"There is very little land cultivated down the valley" of Copiapò; "its wide "expanse supports a wretched wiry grass, which even the donkeys can hardly

flourished round the homestead at Ramadilla. Between that time and the present, the proprietor,—tempted by the high price of fire-wood at Copiapò,—has felled every tree and grubbed up and sold every root on his estate. In May and June, 1857, the river, on entering Ramadilla, afforded rather less than twelve hundred cubic feet of water per minute; but,—thus exposed in a country where a week of occasional showers constitutes an unusually wet season,—it was wholly absorbed by the thirsty soil after a further course of only five or six miles. Even when swollen in summer by streams from melted snow on the Cordillera, it never reaches the sea; but,—oozing through its deep beds of sand and shingle,—forms pools in the deeper parts of its ancient channel.*

The water †—nowhere sufficiently pure for use on the Copiapò and Caldera railway—holds the sulphate of soda largely, and the sulphate of magnesia and common salt more sparingly, in solution. Large establishments are therefore requisite for distilling river-

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" eat. This poorness of the vegetation is owing to the quantity of saline matter " with which the soil is impregnated. Layers of sulphate and carbonate of soda, " even several inches thick, occur in some parts. * * * At present the river con- " tains water enough to reach the sea."—Darwin, *Geology and Natural History of the countries visited by H.M.S. Beagle* (1st Edit.), p. 442 :—(2nd Edit.) p. 362.

* " The Rio de Copiapò, which waters the valley, does not reach the sea, but is " lost in salt pools above twenty miles from the port, and the whole country around " is covered with a thick incrustation of salt ; at some distance from it vegetation " disappears. Between this place and the sea the country is a complete desert. " At the village of Ramadilla the water becomes drinkable, and the whole aspect " of the valley is changed, it being covered with a vigorous vegetation, as far as " the water reaches. The width of the valley is from one to two miles, and that of " the river varies from twenty to thirty feet."

Dr. Mayen, *Journal of the Geographical Society*, vi. (1836) p. 369.

† Analysed by J. Barclay Montgomery, Esq., M.D.

water at Piedra Colgada, and sea-water at Caldera,* for service in the locomotive boilers.

Since the trees have been destroyed and the stream has been more rapidly dissipated and absorbed than before, several reedy swamps, between the Ramadilla house and Piedra Colgada,—formerly frequented by flights of beautiful wild-fowl,—have disappeared; and many of the more distant fields have been abandoned to the desert. Near Monte Amargo, a tract of several square miles is covered with a saline crust at least an inch in thickness.

As each successive irrigation from the river deposits its salts, the ground so watered becomes gradually less productive; it is therefore periodically flooded and puddled, when the noxious ingredients pass off in solution. Land thus cleansed bears tolerable crops of wheat, barley, pumpkins, and cabbages, whilst the melilot *(melilotus)*—called by the natives alfalfa, and by the English lucerne—flourishes with extraordinary luxuriance. But unwashed ground, before it is entirely incrusted with salt, yields only a dry, hard, prickly, and bitter grass, on which mules, asses, sheep, and young cattle browse,† and the Guanaco—stealing down

* Although small quantities of brackish water are drawn from wells near the beach, the inhabitants of Caldera obtain their chief supply for domestic purposes from sea-water distilled by the Copiapò and Caldera Railway Company, who realized from its sale; in

1854	£1003	8	5
5	1355	9	1
6	1359	6	11.

Cartas de los Directores a los Accionistas de la Compañia de la Ferro-Carril de Copiapò, 1855-6.

† An attempt to naturalize the llama was made at Ramadilla; but,—like earlier trials near the coast,—it was unsuccessful.

from its home amid the sands and crags of the desert—feeds at night.*

Whilst the lower part of the valley was undergoing these transformations, the upper seems to have suffered little or no change.

Like the Copiopò valley below Ramadilla, every glen and ravine in Chañarcillo exhibits enormous beds of shingle, pebbles, gravel, and sand, deeply scored, as if by running water; † but shorn of the coppice with which it was formerly clad, it now neither affords a trace of verdure nor contains a single well.

As the district is thus destitute of means for working either water or even steam machinery, horse-whims *(pique tornos)* are the only means available for raising ore to the surface; but these are inadequate to the greatest depths.‡

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* Whilst visiting its feeding-grounds the guanaco sometimes falls a prey to the miners, and forms a welcome addition to their meager fare. When taken young it is easily domesticated.

† *Ante*, p. 70.

‡ "The ore and the *deads* which were formerly drawn out of the mine by the "labour of horses, are now brought to the surface by the application of the "steam-engine. The difference of the expense of steam and horses for this "purpose is nearly fifty per cent. From the increased number and the increased "depth of the mines, this work could not possibly be performed at present by "horses."—Carne, *Cornwall Geol. Trans.*, iii. p. 61.

"Since steam has replaced horse-power, winding machinery has accomplished "the same work, at less than one-tenth of its previous expense."

Captain Nicholas Vivian, *Manager of Wheal Towan and Condurrow*, MSS. (1830).

At the *Carn Brea Mines*, there were consumed in five winding-engines, during the first nine months of 1860,—

In mines where *lodes* are systematically wrought,

	tons	cwt.	qrs.	lbs.								
Coal......	722	1	0	0 .. which cost ..	£595	13	9				
Tallow....	0	9	0	4 .. ,, ..	27	12	10				
Hemp	0	4	2	21 .. ,, ..	10	18	9				
Candles	348 lbs. ..			,, ..	9	8	6				
Oil	41¼ gallons			,, ..	8	18	8				
or at the rate of..								£870	3	4 per ann.	

The materials used in different whim-shafts, during one entire year, were—

	tons	cwt.	qrs.	lbs.							
Chain..........	16	3	3	26, which cost	£422	0	0				
Iron plates for buckets & skips	2	0	0	0, ,,	120	0	0				
Rope	2	0	0	0, ,,	80	0	0				
Sundries				,,	25	0	0—	647	0	0	
Estimated wear and tear of steam-engines, at £50 each..								250	0	0	
Cost of machinery and materials								£1,767	3	4 per ann.	

The wages paid during the first nine months of 1860 were—

to Engine-men..........................	£203	5	0			
Kibble-fillers	365	15	0			
,, landers......................	346	10	0			
or at the rate of....................................				1220	13	4 per ann.
Total expense				£2,987	16	8 per ann.

The ingredients drawn out of the mine were—

			tons	
Tin-stone, containing about 0·0175 its weight of tin-ore—about			36,000	per ann.
Copper-ore, ,, 0·5 ,,	fit for the market,		6,000	,,
Rubbish from cross-cuts and unproductive parts of the *lodes*			6,000	,,
		Tons	48,000	per ann.

The produce,—raised one-half from 100-130, the other from 160-200 fathoms deep,—was delivered on the surface, at a cost of about one shilling and three pence per ton.—

Compiled from Account Books at the Mines. Henry Curwen Salmon, Esq., F.G.S., *Mining Journal* (1860, December 15th), xxx. p. 84 (abridged).

At Junge hohe Birke, near Freiberg, the same force applied to ropes of different materials, in a nearly perpendicular shaft, afforded, on an average, the following daily results:—

Depth. fms.	Weight raised with hempen rope	Weight raised with iron-wire rope
46¼	60 tons.	70 tons.
107¼	28 ,,	36 ,,
190	22 ,,	30 ,,

M. Combes, *Traité de l'Exploitation des Mines*, iii. p. 225.

all broken ore is conveyed, in wheelbarrows or by tram-ways,* through horizontal galleries to the shafts.

"At Wheal Friendship Mine in Devonshire there were two inclined planes, "* * * both beginning near the same point on the surface." The one which was first constructed "was about five hundred yards in length, and the perpen- "dicular depth from the surface was six hundred feet, the angle formed with the "horizon being about twenty degrees; but another plane is now in use, which "is six hundred and fifty yards in length, and attains to a perpendicular depth "of about one thousand and twenty-five feet below its mouth, or eleven hundred "below the surface. The inclination which it forms with the horizon varies from "thirty to forty-five degrees. * * * A small track of edge-rails is carried along "the plane from top to bottom; and the ore is drawn to the surface in a wrought- "iron waggon, by the force of a large overshot water-wheel."

Encyclopædia Britannica, Mining, xv. (Eighth Edit. 1858), pp. 225-6.

* "Railways have lately been used in the levels of the *Consolidated Mines*, "*Poldice*, *Treskerby*, *Huel Damsel*, and other mines, and it is estimated that the "expense of work performed by means of rail-carts, compared with that of the "same work done by wheelbarrows, is less than one half."

Carne, *Cornwall Geol. Trans.*, iii. p. 65.

In the mines of *Blanzy*, seven labourers,—of whom two fill whilst five wheel the barrows,—convey 6,400 kilogrammes of coal one kilometre in eight hours, at a cost of ten francs and a half; or at the rate of—

100 tons carried 100 fathoms for £1 : 4 : 6.

Combes, *Traité de l'Exploitation des Mines*, iii. pp. 8, 9.

The ordinary day's work of each *Trammer* on an iron railway at *Roche-la-Molière* is represented by 3,159 *tonnes* (3,159,000 kilogrammes) of coal carried one mètre; 5 hectolitres (400 kilogrammes) are transported 580 mètres, at an expense,—beside loading,—of 20·83 centimes; a rate equivalent to the carriage of

100 tons 100 fathoms for about £0 : 19 : 0.

Ibid, iii. pp. 12-14.

Since tram-waggons have replaced wheelbarrows underground, the same work has been accomplished at about one-fifth of its previous expense.

Captain Nicholas Vivian, MSS. (1830).

The following columns show the cost of conveying one hundred tons one hundred fathoms,—as well by wheelbarrow as by tram-waggon,—in different parts of Cornwall and Devon.

Mine.	Wheelbarrow.	Tram-waggon.	Authority.	
Cornwall.				
Wheal Clifford	£17 0 0 ..	£7 10 0	—Capt. John Richards,	MSS.
North Roskear	5 15 4 ..	1 3 1	—Capt. Joseph Vivian,	,,
Providence Mines	5 0 0 ..	1 7 1	—Samuel Higgs, Esq.,	,,
South Wheal Crofty ..	4 12 4 ..	1 8 5	—Capt. Wm. Rutter,	,,
Devon.				
Wheal Friendship	8 6 8 ..	2 12 6	} Jos. Matthews, Esq.	,,
Other Mines near Tavistock	7 10 0 ..	2 10 0	}	

The same work is therefore accomplished by tram-waggons at (between one-

In Chañarcillo, on the contrary, the few horizontal portions of the works,—presenting still the ragged surfaces left by blasting,—occur at such different depths that they are quite unsuited, either to wheelbarrows or railways; nor, in fact, is one or other used underground in the district.* Attempts to introduce the windlass were immediately forbidden by native mine-owners.†

The system of shafts, galleries *(levels)*, and *winzes*, by which *lodes* are now‡ laid open elsewhere *(Pl. III.*

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fifth and two-fifths) about one-third of the rate paid when wheelbarrows are used.

At *Wheal Clifford*,—where the temperatures of different *levels* (galleries) range from 80° to 100°,—men are unwilling—many indeed are unable—to undertake, even for enormously high wages, the labour they readily and cheaply perform in other—shallower—mines, in which the heat averages less than 65°, and seldom reaches 70°.

* "The enormous expenses of transport would be perhaps diminished more "than two-thirds, if the works communicated with one another by galleries "adapted for conveyance by wheel-barrows and tram-roads. Well contrived "operations would facilitate the extraction of minerals and the circulation of "air; and the men employed in carrying ore might be employed in a manner "more advantageous to society, and less hurtful to the health of the individual."
HUMBOLDT, *Political Essay on the Kingdom of New Spain*, III. p. 240.

† Several *winzes (Ante*, p. 53, Note ‡) opened and fitted with windlasses and buckets, by the English Superintendent *(Ante*, p. 123, Note †), for raising ore from the deeper parts of *Colorada* and *Desempeño* (*Pl. II.*), were dismantled, because the native proprietors preferred the ancient Chilian mode of conveyance; —in bags on the backs of their *(apires)* workmen.

‡ Whilst the miner's works were extended so far only as ore was visible, he extracted all within reach as quickly as possible; and,—having no guide to discovery,—then abandoned his mine. But when it was ascertained that the earthy constituents of richer were essentially different from those in poorer parts of *lodes*, and that the rocks adjoining them presented also each its peculiar character; he—limited no longer to the capricious meanderings of their metallic ingredients alone—now pursued his search, amongst congenial earthy parts of the *lodes* with which the ores were associated, by means of horizontal galleries *(levels)*; and thus, by a straighter,—and therefore a shorter and cheaper,—course attained his object more quickly, and opened, at the same time, passages suitable for either wheel-barrows or tram-roads.

That the present systematic mode of opening mines originated in this manner

fig. 2, 3), is not yet appreciated in Chili, where they are explored by means of *(Chifflones)* pits sunk obliquely at angles seldom more than 60° or less than 40°, and averaging about 50° from the horizon. These, —extended, downward and alternately towards opposite points, for distances and at inclinations determined in each case by the richnesss, hardness, or other peculiarity of the *lode*,—form irregular zig-zags; more easily to be understood from an inspection of *(Pl. II.)* the section than from any verbal description. As there are no ladders in the shafts, the *chifflones* are the only means of access to the works, as well as the only passages through which ore is conveyed to the shafts from distant recesses and depths beyond the reach of horse-power. The Chilian mine-owner declines every prospective advantage, purchased by the smallest present outlay, the floors therefore consist, for the most part, merely of ragged ledges fortuitously left when the passages were first opened; where the surface affords no foot-hold, a step is cut here and there; and, when the

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seems unquestionable. Traces of it occur in works executed at *(Dolcoath) Bullen Garden* (Pryce, *Mineralogia Cornubiensis*, pp. 170—181. Pl. IV.) as early as 1778. But when, where, or by whom the change was made,—if indeed it were entirely accomplished in any one mine,—there are now no means of ascertaining.

"When *Dolcoath*, which had been closed in 1786, was reopened in 1800, I "found that the great mass of copper-ore it formerly yielded had been wrought "by *bottom-stopes* (Pryce, *Mineral. Cornub.* p. 161). Beyond these the *lode*,— "explored to considerable distances in several *levels* and *winzes*,—afforded ore "in many places, which were generally worked by *back-stopes* (Carne, *Cornwall Geol. Trans.*, III. p. 70)."—John Rule, Esq., MSS.

But notwithstanding the system of *levels*, *winzes*, and *back-stopes* prevailed in every other part of Cornwall, *bottom-stopes* were wrought until 1816 in *Wheal Alfred* (Carne, *Cornwall Geol. Trans.*, III. p. 69), and 1840 in *Wheal Vor*.

chifflones are more than commonly steep, trees notched at the sides serve instead of ladders. Over such steps, worn by many weary feet,—lighted by a small lamp, hung in gymbals at one end of a stick that it may be brought near the floor,— the labourer *(apire)* carries nearly two hundred pounds weight of ore in a leathern bag on his shoulders;* aided sometimes by a rail along

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* "The Indian *tenateros* who may be considered as the beasts of burden in the "mines of Mexico, remain loaded with a weight of from 242 to 377 pounds for "a space of six hours. In the galleries of *Valenciana* and *Rayas*, they are ex- "posed to a temperature of from 71° to 77°; and during this time they ascend "and descend several thousands of steps in pits of an inclination of 45°. These "*tenateros* carry the minerals in bags (*costales*) made of thread; and to prevent "their shoulders from being hurt (for the miners are generally naked to the "middle), they place a woollen covering *(frisada)* under this bag. We meet in "the mines with files of fifty or sixty of these porters, among whom there are "men above sixty and boys of ten or twelve years of age. * * * Where the "principal passages unite, two persons (*despachadores*), provided with balances, "keep a book containing the names of all the (*tenateros*) porters. Persons "stationed near the scales judge the weight of each man's load by lifting it. If "the carrier believes his load lighter than the *despachador* he says nothing, "because the error is in his favour; but, on the other hand, if he believes it "heavier than it is estimated, he demands that it shall be weighed, and the "weight thus determined is entered on the book of the *despachador*."—
Humboldt, *Political Essay on the Kingdom of New Spain*, iii. pp. 238–9, 248–9.

"The surface of the strata in the mine, fortunately, was irregular; but so "worn by the miners' feet, when bearing their loads upward, and so much "polished by their sliding down again, that we found it no easy task to avoid "slipping at once from the top to the bottom."—
Hall, *Journal written on the coasts of Chili, Peru, and Mexico*, ii. p. 30.

"The apire takes his load part of the way by a steep passage, but the greater "part up notched poles, placed in a zigzag line up the shaft. According to the "general regulation, he is not allowed to halt for breath, except the mine is six "hundred feet deep. The average load is considered rather more than 200 "pounds, and I have been assured that one of 300 pounds by way of a trial has "been brought up from the deepest mine. At this time the apires were bringing "up the usual load twelve times in the day; that is, 2,400 pounds from eighty "yards deep; and they were employed in the intervals in breaking and picking "ore."—Darwin, *Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H.M.S. Beagle round the World* (2nd Edit.), p. 340.

the precipitous edges of ancient works, or by a strip of hide fastened to a peg in the rock, when his path is steeper or less practicable than usual.

The operations of crushing and cleaning *(dressing)* the ore, — elsewhere cheaply accomplished by machinery, are, at great expense, performed in Chañarcillo by hand; enormous quantities,—too poor to defray this additional cost,—are therefore either left unbroken in the mines or rejected when brought to the surface, which might have been wrought to advantage had the district been but ordinarily supplied with water.*

The numbers of Government concessions for mining purposes *(Pertenencias)*, † of people employed on

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" Sur la totalité du nombre des gens occupés dans le travail des mines, * *
" plus de deux cinquièmes se compose de *chargeurs* ou *apires*, c'est à-dire
" d'hommes d'une force musculaire prodigieuse, dont le travail est fait dans les
" mines de l'ancien continent par des enfants, des animaux ou des machines."
DOMEYKO, *Annales des Mines*, 4me Série, IX. p. 460.

* " It is computed that at Chañarcillo there are more than 300,000 tons of ore " piled in immense heaps, hitherto useless, and occupying the valuable ground in " the vicinity of the mines. They are judged to have a *lei*, or per centage of " pure silver of from 6 marcs, or 48 ounces, to 50 marcs, or 400 ounces, to the " ton, and at present without any available means whatever of reducing them. " * * * These have been picked over and rejected because not of the richest " ore; but are left for more leisurely examination, when mule hire will have be- " come more reasonable and provisions more plentiful."— COLONEL LLOYD, *Report to the Foreign Office on the Mines of Copiapò* (London, 1857), p. 14.

In May, 1857, two experienced Directors of the largest mines in Chañarcillo carefully examined all ore lying rejected on the surface at *Colorada* and *Desempeño;* when one-third of it was found to afford 51 (Troy) ounces (0·00156 its weight) of silver per (Avoirdupois) ton of ore; the other two-thirds,—consisting of earthy and stony matter only,—were worthless.

† " Por el articulo 2° titulo 8° de la Ordenanza de Mineria, se conceden a todo " peticionario 200 varas meditas a nival por el hilo, direccion o rumbo de la " veta."—*Memoria que el Intendente de la Provincia de Atacama presenta al Señor Ministro de Estado* (Copiapò, 1853), p. 127.

them, and their produce at different periods, have been,—

Date.	No of Pertenencias.	No. of persons employed.	Ore extracted. Tons
1842	83*	745*	1008·00*
1851	115†	1677†	3962·75‡
2	—	—	6386·38‡
3—(first six months).	161‡	2911‡	4015·28‡

* The following abstract of Government records affords a view of proceedings at Chañarcillo during the year.

1842	MINES			PERSONS						Ore extracted
	Productive	Unproductive	Total	Officers	Miners	Labourers	Smiths	Water-carriers	Total	Tons
Jan...	14	62	76	106	241	291	6	31	675	76·
Feb...	12	64	76	106	257	323	6	36	728	82·2
Mar. .	11	70	81	110	266	316	6	41	739	68·1
April .	13	75	88	113	284	339	8	42	785	61·8
May. .	12	72	84	118	270	304	7	38	737	91·1
June .	13	68	81	121	271	324	6	37	759	92·05
July . .	15	69	84	126	277	306	10	40	759	85·95
Aug. .	12	82	94	131	273	321	6	41	773	84·2
Sept. .	14	77	91	134	273	332	6	38	783	89·85
Oct. . .	18	66	84	134	274	337	7	37	789	208·6
Nov. . .	14	67	81	129	256	316	9	38	735	
Dec.	12	..	76	39	70	97	2	11	219	168·15
	..	64		79	158	183	6	27	453	
										1108·

Domeyko, *Annales des Mines*, 4me Série, IX. p. 459.

† *Report to the Foreign Office on the Mines of Copiapò*, p. 160.

‡ *Memoria que el Intendente de Atacama presenta al Señor Ministro de Estado*, p. 121.

Many of these *(Pertenencias)* tracts adjoin the principal mines,* and are traversed by their *lodes* and *branches;* but from the cost of operations necessary to continued possession, and the inadequacy of their returns, numbers of them are abandoned within one year.†

(*b.*) From 1842 to 1853 the mining population continued to increase; but in 1857 it had already materially diminished.

Throughout the rich, but barren, mining districts of Atacama officers and workmen would often want alike the common necessaries of life if they were dependent on such casual supplies only as hawkers would bring on the chance of finding individual customers. The proprietors of mines are therefore obliged to procure from a distance food and water for all their people. The monthly cost of rations averaged at *Colorada* *(Table V.)*, during 1856, about one pound and twelve shillings per man.

The rates of wages mentioned by M. Domeyko ‡ in

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* *Ante*, pp. 123-4.

† The mining privileges officially conceded and relinquished in the silver region of Copiopò only, numbered in two years,—

	1851.	1852.
Concessions	312	767.
Relinquishments	173	392.

Memoria del Intendente de Atacama, p. 101.

‡ "Tout est tellement cher à Chañarcillo, que les frais d'exploitation y montent "à 70 et 75 piastres" (14 ou 15 £) "par mois, par chaque *barretero* (c'est-"a-dire par chaque piqueur ou *barretero*, et le chargeur qui lui correspond, y "compris l'eau, la poudre, la surveillance de la mine, etc.). Il en résulte qu'ayant "en 260 barreteros dans le mines de Chañarcillo en 1842, les frais généraux "d'exploitation ont dû monter cette année à 260 × 75 × 12 = 230,000 piastres "par an. En y ajoutant: 1° le surplus de chargeurs (*apires*) dont le nombre "excédait celui de barreteros de 56 et qui devaient coûter 12 × 56 × 22 =

1842, and Colonel Lloyd* in 1851–2, are neither reconcilable with one another, nor with those paid, workmen of the same classes, at *Colorada*, in 1856 *(Table V.)*.

The *(apire)* labourer,—generally of native Indian, but sometimes of African, extraction,—who accompanies every *(barretero)* miner, aids in culling the ore and afterwards carries it to a shaft or the surface on his back.

The Chilian miner,—using a hammer with one hand and his borer with the other,—himself † bores

"14,784 piastres; 2° environ 20,000 piastres en frais extraordinaires, machines, "etc. On obtient pour frais généraux d'exploitation 268,784 piastres."

DOMEYKO, *Annales des Mines*, 4me Série, IX. p. 461.

* "DESCUBRIDORA MINE.

		Per month.
1 Administrador		£ 60
1 Accountant		20
36 Mayordomos and Watchers, from £4 0 0 to £10 0 0 each		216
70 Miners, English,	£9 0 0 to £10 0 0 ,,	290
Native,	2 8 0 to 3 8 0 ,,	
50 Peons	3 0 0 ,,	150
60 Labourers	2 6 8 ,,	140
3 Blacksmiths	10 0 0 ,,	30
2 Carpenters	10 0 0 ,,	20
7 Servants	2 11 5 ,,	18
Labour alone, per month		£944

"SALVADORA MINE,
belonging to Chileans; administered by a Cornish Captain.

	Per month.
Administrador	£ 21 0 0
4 Mayordomos	29 8 0
71 Miners & Labourers, of whom 10 were English	225 12 0
Rations, materials, coal, general disbursements, and carriage	109 16 0
Total, per month	£385 16 0

LLOYD, *Report to the Foreign Office on the Mines of Copiapò*, pp. 18, 19.

† Saint Just is now the only part of Cornwall in which, as in Chili, the hole for blasting is bored by a single workman.

the holes for blasting; but at times he is relieved by his assistant, who handles the boring-tools, whilst he gleans the ore.

When the Cornishman is not engaged in directing other workmen, he is employed in sinking shafts or on some other special work requiring skill and expedition. Less independent, however, than the native miner, he needs the aid of a comrade * in boring his hole; each in turn,—as usual in Cornish mines,—guiding the borer and striking it with a heavy two-handed *mallet*. But though the Cornishman uses less gunpowder, his day's work is nearly one-third greater than that of the native miner.

(*c.*) The quantities of silver produced † and silver-ore exported ‡ from the department of Copiapò, between 1830 and 1853, are shown in the following columns.:—

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* The Cornish miner—expert at the use of pick and *gad* (wedge),—widens the joints,—picks thin slices from between their smooth, hard sides,—and opens every softer seam of rock. Having thus destroyed the support afforded by natural structure, he so places his hole that its blast shall act at the greatest advantage on those parts which now offer least resistance; and if two holes be necessary, their explosions are so timed that the first shall make way for the second. The charge also is adjusted merely to rend, without displacing the rock; so that its pieces may be afterwards removed by aid of pick and sledge only.

As the native miner is unskilled in using the pick, he requires more powder than the Cornishman to do the same work.

† *Memoria del Intendente de Atacama*, p. 122.

‡ *Ibid*, pp. 113, 114, 122.

Years.	Silver produced. lbs. (Troy).*	Silver-ore exported. Ore. Tons (Avoirdupois).	Official estimate of Silver therein. lbs. (Troy).
1830	4,104·6	—	—
1 ..	3,696·6	—	—
2	20,202·1†	—	—
3 ..	58,034·2	—	—
4	51,027·3	—	—
5 ..	52,209·8	—	—
6	10,604·9	—	—
7 ..	36,028·4	—	—
8	39,213·0	—	—
9 ..	63,961·6	—	—
1840	11,865·0	—	—
1 ..	50,614·4	—	—
2	51,063·3	—	—
3 ..	42,655·2	—	—
4	75,814·3	—	—
5 ..	94,586·0	—	—
6	99,114·2	—	—
7 ..	125,811·3	—	—
8	160,946·8	—	—
9 ..	210,958·6	—	—
1850	238,561·6	—	—
1 ..	218,034·6	2,725·86	113,646·4
2	243,908·9	4,818·53	200,895·1
3 (4 months)‡	72,408·0	2,032·84	84,753·5
	lbs. 2,035,424·7	tons 9,577·23	lbs. 399,295·0 §

Total produce of Silver in twenty-three years and four months ... } lbs. 2,434,719·7.

* *Memoria del Intendente de Atacama,* p. 122.

† Silver was first found at Chañarcillo in 1831–2 (*Ante,* p. 69).

‡ The account of exports relates to four months only; but the mining returns include half the year 1853. *Memoria del Intendente de Atacama,* pp. 121–2.

§ Between 1st Jan. 1851, and 30th June 1853, the department of Copiapò yielded 19,335·8 tons of silver-ore; of which—

Chañarcillo	afforded	14,364·41	tons,	or the	0·7429 part;
Tres Puntas	,,	3,814·25	,,	,,	0·1973 ,, ;
San Antonio	,,	513·66	,,	,,	0·0266 ,, ;
Romero	,,	341·84	,,	,,	0·0176 ,, ;
Sacramento	,,	301·64	,,	,,	0·0156 ,, .
Total....		19,335·8	tons.		1· *Ibid,* p. 121.

Notices of Copper-Mines near Copiapò, in Chili.

The copper-deposits of Copiapò* occur in felspathic, quartzose, and hornblendic rocks, which,—commonly lamellar but sometimes massive,—form high craggy hills on either side of the valley.† Beyond these the rocks north and south are in great measure overspread with sand,‡ much of which is unconsolidated. In one spot at least,—el Bramador§ near Toledo,—loud noises may sometimes be heard when large quantities of it are drifting || before heavy gales.

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* Heaps of wood-ashes and copper-slag mark the sites of many ancient smelting-works in the valley of Copiapò.

When copper was first discovered at *la Marquesa*,—the most ancient mine in Vallenar,—is now unknown; but *el Cobre* and *Larraona*, in the same department, were wrought during the year 1700; and other copper-mines were opened there soon after.—*Memoria del Intendente de Atacama*, p. 11.

† Domeyko, *Annales des Mines*, 4me Série, IX. pp. 366, 374.

‡ Hall, *Journal written on the Coasts of Chili, Peru, and Mexico, in the years* 1820,-21,-*and* 22, II. p. 21 (*Ante*, p. 139, Note). Domeyko, *Annales des Mines*, 4me Série, IX. p. 365.

§ "I heard an account * * * of a hill in the neighbourhood * * * called "'El Brenador,'—the roarer or bellower; * * * as far as I understood it was "covered by sand, and the noise was produced only when people, by ascending "it put the sand in motion."—Darwin, *Geology and Natural History of the Countries visited by H.M.S. Beagle* (2nd Edit.), p, 361.

At Reg Ruwan, in Cabool, "hollow sounds, such as would be produced by a "large drum, are heard when the sand is set in motion."

Burnes, *Personal Narrative of a Journey to and Residence in Cabool*, p. 157. *Edin. New Phil. Journal*, XXXIII. p. 204.

|| "At Nakous in Arabia Petræa * * * a bare mountain composed of hard "sandstone * * * presents on two sides surfaces so inclined that the white "and slightly adhering sand which covers it scarcely supports itself, and slides "down with the smallest motion; or when the burning rays of the sun destroys "its feeble cohesion. These sandy declivities are about 150 feet high. * * * "I climbed with difficulty seventy or eighty feet, * * * and in climbing heard "the sound beneath my feet, which made me think the sliding of the sand was

About three miles from Baranquilla, on the coast, a low but steep escarpment presents several nearly horizontal beds of recently formed sandstone; which—pierced here and there by dark hornblendic crags—extend several miles inland, as far as Copiapò valley below Monte Amargo. This sandstone is traversed by an infinite number of small irregular joints; and wherever these occur,—harder perhaps than elsewhere,—it rises slightly above the general level.

At about three hundred feet above the sea some beds of this highly calcareous sandstone enclose near *Quebrada Seca* considerable quantities of broken and ill-preserved shells.*

Near Caldera, in a railway-cutting one hundred and eighty feet above high-water mark, large tracts of loose sand, several feet in depth, contain tolerably perfect shells in such enormous abundance, that they not only furnish lime,† to the whole neighbourhood, but are shipped to Coquimbo, Valparaiso, and other

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" the cause and not the effect * * * I therefore slid down as fast as I could, and " endeavoured with the help of my hands and feet to set the sand in motion. " This produced an effect so great, and the sand in folling under me made so " loud a noise, that the earth seemed to tremble. * * * It appeared to me to " have the greatest analogy to the humming-top; but rose and fell like the sound " of an Eolian harp."—SEETZEN (Monatliche Correspondenz, Oct. 1812, p. 393), *Edinburgh Journal of Science*, VII. (1827) pp. 51–3.

The same phenomena are described by Mr. Gray.—Daubeny, *Description of Active and Extinct Volcanoes*, p. 437. *Edinburgh Journal of Science*, VI. p. 154.

* In several extensive, level, and horizontal beds of shells, elevated from 60 to 230 feet above the sea near Valparaiso, the state of decomposition has an evident relation to the comparative height at which they are found.—DARWIN, *Proceedings of the Geological Society* (Abridged), II. (1837) p. 447.

† " At Quintero near Valparaiso the sand contains beds of shells in a semi- " fossil state, which are burnt by the natives for lime."

CUMING, *Geol. Trans.*, 2nd Series, V. p. 265.

ports, with a like object. The same beds, in some parts so full of shells, are in others made up almost wholly of gravel, pebbles, shingle, and fragments of rock which have been bored by marine animals.

Specimens from each of these deposits * were obligingly examined by Robert Etheridge, Esq., F.R.S.E.; F.G.S.; of the Ordnance Geological Survey, who observes ;—

" The shells from *Quebrada Seca* are so rounded and worn that it " is almost impossible to determine their generic much less their " specific characters. Those from Caldera appear to be more modern " and are better preserved. I find amongst them the following ;—

Quebrada Seca. (300 feet above the sea)	Caldera. (180 feet above the sea)
Panopea.	*Donocilla donacinum.*
Venus.	*Venus.*
Crassatella.	*Turbinella.*
Isocardia.	*Oliva Peruviana.*
Balanus.	*Turritella.*
	Purpura.
	Pecten.
	Mactra Byronensis.
	Balanus.
	An argillaceous rock, bored by *Pholas* or *Lithodomus.*

" They are of species which appear to be now living in the Chilian " and Peruvian provinces,—are entirely marine,—and undoubtedly " come from raised-beaches along the coast."

The beds of shells and their equivalents, perhaps, mark, and their depth may be in proportion to, the intervals of repose; the sand,—almost destitute of

* All these have been placed in the Museum of Practical Geology (Jermyn Street, London).

shells,—was, on the other hand, probably deposited during periods of elevation.

The frequency of earthquakes, and the terrific effects they have often produced, on the coast of Chili are generally known.*

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* De Ulloa, *Voyage to South America*, II. p. 257. Mrs. (Graham) Callcott, *Geological Transactions*, 2nd Series, I. p. 413. *Letter to the President and Members of the Geological Society* (London, 1834), pp. 1–9. Hall, *Journal written on the Coasts of Chili, Peru, and Mexico*, II. p. 25. Scrope, *Considerations on Volcanos*, pp. 190, 208. Caldcleugh, *Philosophical Transactions*, CXXVI. (1836) p. 21. *Proceedings of the Geological Society*, II. (1837) p. 444. Lyell, *Principles of Geology*, I. p. 401. Bakewell, *Introduction to Geology* (4th Edit.), p. 98. De la Beche, *Geological Manual* (3rd Edit.), p. 143. Greenough, *Proceedings of the Geological Society*, II. (Presidential Address, 1834) p. 56. Alison, *Ibid*, II. (1835) p. 209. Darwin, *Ibid*, II. (1837) p. 447. *Geol. Trans.*, 2nd Series, V. p. 601. *Natural History of the Countries visited by H.M.S. Beagle* (2nd Edit.), pp. 301–312, 351. Fitz-roy, *Jour. of the Royal Geographical Society*, VI. p. 319. *Surveying Voyage of H.M.S. Adventure and Beagle*, II. 402–418.

At 8 a.m. on the 5th of October, 1839, an earthquake destroyed, in a few minutes, within the city of Copiapò alone, property valued at (£300,000) one million and a half of dollars; beside much more in the neighbourhood. Its effects were most disastrous along and near the valley which reaches from the Cordillera, through Pabellon, Copiapò, and Ramadilla, to the ocean; but—diminishing at greater distances on both sides of that line—they were felt, more or less severely, throughout Atacama. As far north as the confines of Bolivia,—ninety miles, at least, from the centre of disturbance,—shocks were perceived twelve or fifteen miles off the shore. At Coquimbo—about the same distance south,—on the contrary, they were scarcely noticed.

During the first shock,—which lasted at least two minutes and a half—people with difficulty saved themselves from falling. Throughout that day and the night succeeding, shock followed shock with scarce an intermission; and for nearly a week there were fully one per hour. In about a fortnight they became much less frequent; but for four months three or four shocks were felt daily.

A dull rumbling noise like thunder, or separate reports as of artillery at a distance, often accompanied the shocks; but there were also shocks without noises, and noises without shocks. It is not easy to describe one phenomenon observed at Caldera; whilst the convulsion was most severe; which may, however be likened to a sudden concussion occasioned by the fall of an enormous weight from a great height.

The first shock,—beyond comparison the most severe,—passing from north-east to south-west, destroyed or irreparably damaged, not only every tall chimney in the Mexican and South American Company's, Messrs. Livingstone & Company's, and Messrs. Taglè & Company's copper-smelting works,—but also every

During my brief stay in that country, seldom more than three days passed without a shock One only of them was however severe enough to dislodge portions of the ceiling in my room; and to show,—by the way in which it tilted my bed,—that its direction was from south-west to north-east. Another was noticed both at Copiapò and Chañarcillo,—places more than thirty miles apart,—whilst I was underground in *Colorada;* but it was not felt beneath the surface. The injuries occasioned by earthquakes, are, however, often severest in the shallowest parts of mines.

That this coast has been more than once appreciably elevated, within the last forty years, seems unquestion-

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wall erected on the deep beds of sand and shingle, east of the harbour. But whilst buildings parallel to its course crumbled into irregular heaps, those at right-angles to it were simply laid flat, the bricks and moulded masses of copper-slag of which they were constructed retaining their relative positions unchanged. South of the harbour, contrariwise, the Copiopò Company's stacks and smelting-houses,—founded on greenstone,—were uninjured. The native huts, of wood, were scarcely moved.

The air was filled with clouds of dust, during a moment of unnatural stillness, after the first shock.

At Caldera the sea gradually fell, from about quarter flood, beyond the ordinary level of low-water, leaving vessels aground and boats dry on the beach; then—slowly returning—it rose, some nine feet and a half perpendicular, to the usual high-water mark; and thus ebbed and flowed six times within an hour.

The affrighted inhabitants escaped to higher grounds; and remained several days and nights in the dreary desert of Atacama.

Along the great line of disturbance between Pabellon and Caldera several shallow copper-mines were destroyed and others were much injured. At Flamenco and Chanaral on the coast northward many were greatly damaged. In the neighbouring districts of Tres Pantas and Chañarcillo, on the contrary, deeper works were but slightly affected.

Near Caldera the coast seems to have been permanently raised; for rocks which were covered by the sea at high-water before the earthquake, are now at least a foot above the highest tide.

Richard Johnstone, Esq., M.D.; and John Jos. Murray, Esq., H.M. Consul at Caldera; MSS.

able*; but whether the present positions of the several beds of shells † and other marine remains which

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*Mrs. (Graham) Callcott, *Geol. Trans.*, 2nd Series, I. p. 413. Caldcleugh, *Phil. Trans.* CXXVI. (1836) p. 21. Fitzroy, *Journal of the Royal Geographical Society*, VI. p. 319. *Surveying Voyages of H.M.S. Adventure and Beagle*, II. pp. 412, 414. Darwin, *Geol. Trans.*, 2nd Series, V. p. 601. *Natural History and Geology of the Countries visited by H.M.S. Beagle* (2nd Edit.), pp. 301–312. *Ante*, p. 158, Note.

† "Between Talcaguana and Conception, within four or five leagues from the "shore * * * at a depth of half or three quarters of a yard beneath the surface "of the ground, is a stratum of shells of different kinds, two or three toises in "thickness, and in some places even more, without any intermixture of earth, "large shells being joined together by smaller, and which also fill the cavities "of the larger. From these shells all the lime used in building is made; and "large pits are dug in the earth for taking out those shells, and calcining them. "* * * Quarries of the same kind of shells are found * * * fifty toises, * * * "and I saw them myself at the height of twenty toises above the surface of the "sea. * * * The various sorts of shells which compose these strata both in "the plains and mountains, are the very same with those found in the bay and "neighbouring places, * * * at the bottom of the sea in four, sixteen, and twelve "fathom water."—De Ulloa, *Voyage to South America*, pp. 252–4.

"Several ancient lines of beach, consisting of shingle mixed with shells, "extend in a parallel direction to the shore, to the height of fifty feet above the "sea."—Mrs. (Graham) Callcott, *Geol. Trans.*, 2nd Series, I. p. 415.

"At the mouth of the Rapel sixty miles south of Valparaiso, dead barnacles "occur adhering to the rocks three or four feet above the highest tidal level; "and in the neighbouring country marine shells are scattered abundantly to the "height of about one hundred feet. Ten miles to the north, and at an equal "distance from the sea, is the village of Bucalemu, in the neighbourhood of "which are very extensive beds of recent shells. At the bottom of the great "valley of Maypo, and some miles from the coast, marine shells of existing "species are also numerous; and at San Antonio near the northern point of "that river, are large quarries of shells. * * * Shells of various kinds, but all "similar and in similar proportional numbers to those on the beach, form numer- "ous beds, elevated from sixty to two hundred and thirty feet above the sea, along "the bold granitic coast south of Valparaiso. * * * Near Viña del Mar, *Balani* "were discovered adhering to the stone about fourteen feet above high water; "and in the same neighbourhood there is an abundance of elevated shells." Darwin, *Proceedings of the Geological Society* (Abridged), II. (1837) pp. 446-7.

"Near Coquimbo five narrow, gently sloping, fringe-like terraces rise one "behind the other; which, where best developed, are formed of shingle. * * * "At Guasco, north of Coquimbo, the phenomenon is displayed on a much grander "scale. * * * The terraces are there much broader, and may be called plains; "in some parts there are six of them, but generally only five; they run up the "valley for thirty-seven miles from the coast. * * * Shells of many existing

overlie many of the copper deposits* are the results of repeated displacements by earthquakes; or may rather be due to a constantly progressive action,† like that by which Scandinavia still rises,‡ is beyond the scope of this enquiry.

Beneath a low steep cliff of shelly calcareous sandstone,§ about three miles from the sea and three hundred

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"species not only lie on the surface of the terraces at Coquimbo (to a height of "250 feet), but are imbedded in a friable calcareous rock, which in some places "is as much as between twenty and thirty feet in thickness, but is of little "extent. These modern beds rest on an ancient tertiary formation containing "shells, apparently all extinct. * * * I found no regular strata containing "sea-shells of recent species, excepting at this place, and at a few points north-"ward on the road to Guasco.—Darwin, *Natural History and Geology of the Countries visited by H.M.S. Beagle* (2nd Edit.), p. 343 (Abridged).

Hall, *Journal written on the Coasts of Chili, Peru, and Mexico*, II. p. 6.

* "At Quintero * * great beds of shells, which stand some yards above the "level of the sea, are burnt for lime. The proofs of the elevation of this whole "line of coast are unequivocal; at the height of a few hundred feet old-looking "shells are numerous, and I found some at 1300 feet. These shells either lie "loose on the surface, or are imbedded in a reddish-black vegetable mould. I "was much surprised to find under the microscope that this vegetable mould is "really marine mud, full of minute particles of organic bodies."

Darwin, *Natural History and Geology of the Countries visited by H.M.S. Beagle* (2nd Edit.), p. 254.

"Near Caldera in Chili an ancient beach now a mile inland and one hundred "and eighty feet above the sea, affords the same *Diatoms* as the present strand. "* * * In Sirocco-dust which fell at Malta Mr. Ralfs found several Chilian "forms."—J. Barclay Montgomery, Esq., M.D., *Annual Reports of the Royal Cornwall Polytechnic Society*, Part XXV. (1857), pp. 45, 47.

† Darwin, *Proceedings of the Geological Society*, II. (1837) p. 448.

Natural History and Geology of the Countries visited by H.M.S. Beagle (2nd Edit.), pp. 310, 344.

‡ Von Buch, *Travels through Norway and Lapland*, pp. 217, 386. Lyell, *Principles of Geology*, II. p. 307. *Reports of the British Association*, III. (1834) p. 652. *Phil. Trans.*, CXXV. (1835) p. 1. Keilhau, *Edin. New Phil. Journal*, XX. p. 425. Elie de Beaumont, *Ibid*, XXV. p. 301. Forchhammer, *Geol. Trans.*, 2nd Series, VI. p. 157. *Quarterly Journal of the Geological Society*, I. pp. 376, 379. Eugene Robert, *Edin. New Phil. Journal*, XXVIII. p. 386. Böhtlingk, *Ibid*, XXXII. p. 105. Nilsson, *Quarterly Journal of the Geological Society*, VII. Part II. p. 112.—Domeyko, *Annales des Mines*, 4me Série, XIV. pp. 153–162.

§ Domeyko, *Annales des Mines*, 4me Série, IX. p. 366. *Ante*, pp. 155–6.

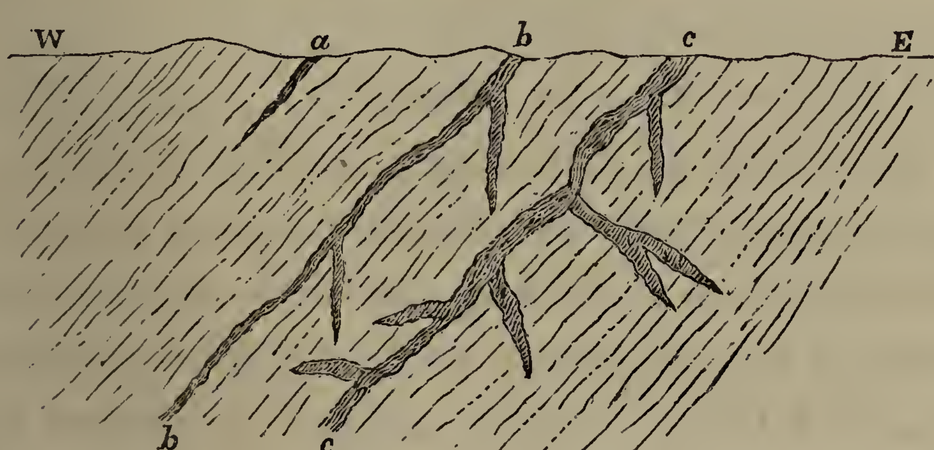
feet above its present level, the mine of

QUEBRADA SECA.

is wrought in thickly foliated rocks; which, southward, are very hard when—sparingly mixed at intervals with small garnets—quartz and hornblende are their chief ingredients; but are much softer, towards the north, where felspar prevails.* Calcareous spar, plentiful throughout the district, is especially so towards *Cerillas*, an adjoining mine, on the north.

Structural planes, common to the whole formation however varied its composition, approximately coincide, both in *strike* and in dip, with the nearest metalliferous masses. But all these are not strictly parallel; † for the *Vetas* and the *Guia* (*Fig.* 10, *a*, *b*) bear 35° N. of E. and S. of W., whilst the *Manto* (*c*) takes a nearly meridional direction; their general dip however is 30°–55° west.

Fig. 10. (*Transverse Section.*)



a. Veta. *b. Guia.* *c. Manto.*

* "C'est dans les masses granitiques associées aux roches porphyritiques et "feldspathiques compactes, qu'on est encore en train d'exploiter les mines * * * "de la Quebrada Seca et beaucoup d'autres du côté du Sud."

DOMEYKO, *Annales des Mines*, 4me Série, IX. p. 367.

† *Ante*, p. 22.

Within a breadth of four fathoms on the west, three *(vetas)* veins (*a*)—each from two to ten inches wide, composed in great measure of quartz, but containing also earthy brown iron-ore, the green carbonate of copper, copper pyrites, and vitreous copper-ore,—have been opened and abandoned.

East of these, the *Guia* (*b*),—sometimes as much as three feet, but averaging about a foot in width,—also consists for the most part of quartz mixed with hornblendic, calcareous, and felspathic matter; and,—in its shallower parts, with earthy brown iron-ore. Small lumps of native copper incrusted with red oxide of copper, and coated with earthy black copper-ore, are sometimes mixed with massive green carbonate of copper, in a matrix of *(gossan)* siliceous brown iron-ore, near the surface; but the principal produce,—of black* and green chrysocolla, Atacamite,† purple and vitreous copper-ore, and copper pyrites—occurs in quartz and felspar at greater depths.

Still further east, the *Manto* (*c*),—generally about nine, but enlarging at intervals to thirty feet in breadth, —also contains great quantities of quartz, mixed, however, with earthy brown iron-ore and ingredients common to the adjoining rocks far more abundantly than in the *Guia*. Native copper is invested by the

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* Domeyko, *Annales des Mines*, 4me Série, XVIII. p. 123.

† "Atacamite is often produced when metallic copper or copper-ores have been "exposed to the action of the atmosphere, or of sea-water."

Mohs, *Mineralogy* (translated by M. Haidinger), III. p. 75.

Domeyko, *Annales des Mines*, 3me Série, XVIII. p. 123.

oxide and green carbonate of copper, in a matrix of earthy brown iron-ore, granular quartz, and felspar clay near the surface; whilst the silicate, chloride, and sulphurets of copper are disseminated through felspathic, quartzose, and hornblendic matter below.

On either side, but especially east, of the *Guia* (*b*) and *Manto* (*c*), several large *lode*-like masses of veinstone extend through the rock obliquely to its foliation. They do not however reach from one to the other, or mutually intersect; but become gradually less and less metalliferous,—slowly assimilate to the *Country* in mineral character,—and ultimately disappear. Smaller metalliferous branches, without number,—springing from the larger off-shoots as well as from the *Guia* and *Manto*,—every where traverse the intermediate rock.

Northward, where lime becomes a large ingredient in the rock, the *Guia*, the *Manto*, and their *branches*, —alike destitute of metalliferous quartz,—are represented by thin and irregular plates of calcareous spar; merely tinged with the green carbonate of copper.

All works less than fifteen fathoms deep are open to the day; whilst to an equal depth beneath the whole formation is irregularly honeycombed in all directions by the miners.

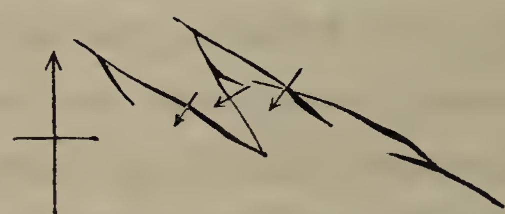
The deepest pits contain a little water much contaminated with the sulphate of soda and other salts; but the surface is destitute of both vegetation and moisture.

Surrounded by high hills of sand drifted from the desert, though only twenty miles west-north-west of Copiapò,—the copper-mine of

SAN JOSÈ

has been sunk in a fine-grained massive crystalline rock, composed chiefly of hornblende and quartz; with which the carbonate of lime is, in some places, largely mixed.

Fig. 11. *Plan.*



Scale 40 fathoms to an inch.

Two systems of veins, coinciding in direction with as many series of joints,—bear respectively

25°—30° S. of E. & N. of W.; and
30°—35° W. of N. & E. of S.

Owing to this coincidence * their sides *(walls)* are generally smooth.

Whatever their directions, they all dip 65°–78° south-west; whilst the *shoots* of ore incline towards the north-west.

Their numerous intersections are unattended by displacement *(heave)*; at and on either side of the contact, however, they often enlarge. But rich and regular as

* Dr. Boase, *Cornwall Geol. Trans.*, IV. p. 448; *Primary Geology*, p. 179. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836), p. 89. De la Beche, *Report on Cornwall, Devon, and West Somerset*, p. 339. Henwood, *Cornwall Geol. Trans.*, V. pp. 179–112, 259–262.

some portions are, no vein in *San Josè* has been traced as much as one hundred fathoms in any direction.

A few rich veins are no more than three or four inches wide; but generally they are from two to three feet. A portion of the northernmost vein was indeed opened for a breadth of from fifteen to eighteen feet; in this place, however, it consisted of two principal *branches* enclosing a mass *(horse)* of rock, which minor *strings* of pure ore traversed in all directions.

Their ingredients—partaking, as usual, the characters of the adjoining rocks—are chiefly quartzose and hornblendic; but carbonate of lime, often black, is also abundant. Near the surface earthy brown iron-ore—sometimes yellowish* but mostly brown—is largely mixed with granular quartz, and, less plentifully, with calcareous spar; whilst the sides of numerous small drusy cavities are studded with mamillated and botryoidal masses of malachite. At greater depths lumps and irregular veins of jaspery iron-ore, bluish-green and black chrysocolla, Atacamite, malachite, and vitreous copper-ore are interspersed through the other ingredients.†

Although the veins are wrought to a depth of thirty fathoms without trace of moisture; at less than ten fathoms north-east of them a shaft sunk but five fathoms from the surface, affords copious streams of pure water.

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* *Ante, Table I., Purturburà; Table II., Tilporà.*

† Near Tierra Amarilla copper pyrites occurs in a matrix of specular iron-ore.

Enormous quantities of copper in bars, regulus, and ore are exported from the northern parts of Chili.*

In the shallower parts of *Quebrada Seca, San Josè*, and other copper-mines of the neighbourhood,

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* The mining privileges officially conceded and relinquished in the copper districts of Copiapò, in two years, numbered

	1851.	1852.
Concessions............	89	407;
Relinquishments	61	123;

and one hundred and sixteen copper-mines were wrought by nearly fourteen hundred workmen.—*Memoria del Intendente de Atacama*, pp. 101–2.

" On a extraït de ces mines, dans les dix années, dupuis 1832 á 1842, 2,000,707 " livres de cuivre en barres, et 70,000,000 livres de minerai de cuivre cru qu'on " exporta en Angleterre, et dont le loi moyen a été d'environ 23 à 25 p. 0|0."

Domeyko, *Annales des Mines*, 4me Série, ix. p. 370.

The quantities exported, were — in 1850,

Ports.	Copper in bars. Tons.	Copper-regulus. Tons.	Copper-ore. Tons.
Coquimbo	4739·54	1676·67	886·71[a]
Huasco	548·74	298·65	1531·95[a]
Caldera	17·15	—	1168·72[a]
Total....	5305·43	1975·32	3587·38
	in 1852,		
Coquimbo	2923·06	2632·54	7644·57[b]
Huasco and Caldera ..	469·84	2645·86	5367·86[c]
Total....	3392·90	5278·40	13012·43
	and in 1857,		
From all these ports ..	2167·	17910·	21385·[d]

" besides large quantities to France, the United States, and Hamburgh."

a M. Cazotte, French Consul General in Chili; *Annales des Mines*, 4me Série, xx. pp. 84-7.
b " " *Ibid*, 5me Série, iv. p. 520.
c *Memoria del Intendente de Atacama*, p. 114.
d *Universal Review*, iv. (No. xv. May 1860) p. 648.

The copper-ores purchased at various establishments of the Mexican and South American Company in Chili, during

1848 } 1849 } contained .... 26·560 of copper.
1850 " .... 31·302 " .
1851 " .... 23·551 " .
1852 " .... 13·946 " .
1853 " .... 15·619 " .
and averaged for the whole period.......... 17·255 " .

Alison, *Letter to the Mexican & South American Co.* (London, 1856), p. 46.

gold* is sometimes mixed with ferruginous quartz; but rarely in quantities sufficient to make it an object of special pursuit.

Regulus manufactured by the same Company, in

1855 contained	....	from 62·4 to 71·0	of copper.
1856 ,,	....	,, 58·0 ,, 67·8	,, .

ALISON, *Letter to the Mexican & South American Co.* (London, 1856), pp. 75–6.

The dry method of assay only is practised in Cornwall;—the wet alone in Chili.

"The Chilian miners have the reputation of being great cheats; and the most "serious frauds are committed in the sale of copper and silver ores by bribing "the samplers; and, the mode of sampling being imperfect, the frauds are not "detected if the ores get into the native furnaces, or until the exported ores "arrive at Swansea."—*Universal Review*, IV. (No XV., May, 1860) p. 649.

* "On compte trois époques dans l'histoire de l'industrie minérale de Copiapò. "D'abord, du temps des premiers conquérants et sous le régime colonial espagnol, "on n'y travaillait que des mines d'or. Il paraît qu'on avait trouvé des quan- "tités immenses de ce métal aux affleurements des filons. Secondement, vers la "fin du dernier siècle, l'epuisement des principaux filons aurifères, ou plutôt "l'appauvrissement des minerais dans la profondeur (fait généralement observé "dans toutes les mines d'or du Chili); ensuite, la découverte des mines de "cuivre (dont les filons se trouvent dans les mêmes localités que les filons d'or); "celle enfin des quelques mines d'argent, firent abandonner les mines d'or, et on "commença à s'appliquer à l'extraction du cuivre et de l'argent. * * * Les "minerais d'or donnaient, terme moyen," (0·00003125) "pour 58 piastres d'or "par caisson (ce qui que revient à peu prés à 20 castillanos, c'est-à-dire à 2 "dixièmes de livre d'or par 64 quintaux). Quant aux minerais de cuivre, on "n'extrayait que des minerais oxydés ou autres contenant au moins 30 p. 0|0 "de cuivre."—DOMEYKO, *Annales des Mines,* 4me Série, IX. pp. 368–9.

"At Coquimbo gold is found in a matrix of carbonate of copper."
CALDCLEUGH, *Travels in South America,* I. p. 351.

On the Gold-Mines of Minas Geraës, in Brazil.

The richest gold-field in Brazil,—between Congonhas do Campo* on the south, Candonga on the north, the Rio das Velhas and other tributaries of the Rio São Francisco on the west, and several branches of the Rio Doce on the east,—is about one hundred miles in length, and from fifty to seventy in width. Beyond the confines of this region also many mines have been opened; and some of them are still productive.

That part of the district which consists of (*Campos*†) undulating table-land and low rounded hills,—between two and three thousand feet‡ above the sea—is covered with (*Capim*§ *gordura. Trigestis glutinosa*, Nees; *Agrostis glutinosa*, Fisch; *Suardia pieta*, Schrank; ||

* "Man pflegt daher an dieser Grenze sehr viele Orte mit dem Beinamen: "*do Mato dentro* oder *do Campo* zu unterscheiden."
von Spix und von Martius, *Reise in Brasilien*, II. p. 423.

† Mawe, *Travels in the interior of Brazil*, p. 225. von Spix und von Martius, *Reise in Brasilicn*, I. p. 395. Auguste de Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes*, I. pp. 111, 195. Caldcleugh, *Travels in South America*, II. p. 218. Gardner, *Travels in the interior of Brazil*, pp. 479 491, 495.

‡ von Spix und von Martius, *Reise in Brasilien*, III. Geographischer Anhang, pp. 39, 40.

§ "A Rio de Janeiro, cette plante porte le nom de *Campim melado*. Le mot "guarani *capim*, ou, pour être plus exact, *capyi (Thes. de la leng. guar.)*, signifie "herb, foin. Cette expression s'est introduite parmi les Brésiliens, quoiqu'elle "ne fût pas nécessaire dans leur langue, puisque l'on a en portugais le mot *feno*. "L'habitude de vivre parmi les Indiens a pu seule faire adopter aux Portugais "le mot *capyi*."—Saint Hilaire, *Voyage dans les provinccs de Rio de Janeiro et de Minas Geraes*, I. p. 194.

|| *Ibid*, I. p. 194; II. pp. 291, 311. von Spix und von Martius, *Reise en Brasilien*, I. p. 401; II. p. 423.

Melinis minutiflora, Gardner.*) coarse grass and irregularly dotted with *(Capões*†*)* natural clumps of shrubs; the remainder — rising into isolated peaks and deeply serrated ridges five or six thousand feet high,‡—is, in many places, still richly clothed with

* "The hills around the Cidade do Serro, are covered with a grass which the "Brazilians call Capim gordura *(Melinis minutiflora*, Nees ab. E.). It is covered "with an oily viscous matter, and universally makes its appearance in those "tracts, which have been cleared of virgin forest for the purposes of cultivation; "both cattle and horses are very fond of it, but although they soon fatten on it, "the latter get short-winded, if they feed on it for any length of time. Martius "considers this plant to be truly a native of Minas Geräes, while St. Hilaire is "of a different opinion; as it is now everywhere so common in this province, it "is a difficult matter to say which of those excellent botanists is in the right; "all the agriculturalists that I have spoken with on the subject agree with St. "Hilaire, although they differ in opinion in regard to the place of its original "growth. * * * It is rapidly extending northwards * * * but is not to be met "with at all in the Sertão."—GARDNER, *Travels in the interior of Brazil*, p. 477.

† "Der Abhang ist mit Grascampos und einzelnen Gebüschen bedeckt, und "hie und da nimmt eine dichte Waldung von niedrigen, stark belaubten Bäumen "die Rinnsale und die Vertiefungen ein. Diese Wäldschen, welche man hier "zu Lande (von dem verdorbenen Worte der Lingua geral *Caapoão*, Insel) "*Capões*, gleichsam Waldinseln, nennt, bilden einen eigenen Zug in der Land-"schaft der Camposgegend, und bestehen grösstentheils aus Pflanzenarten, "welche nur in ihnen vorkommen. * * * Hieher gehören mehrere Arten der "Gattungen Laurus, Vochisia, Annona, Uvaria, Xylopia, Myrtus, Inga, Wein-"mannia, Styrax, Bauhinia, Coccoloba, Chiococca, Amajovea, Chomelia, Sapium, "Gymnanthes, Spixia, von Ranken der Paullinien und Echites durchschlungen."
VON SPIX und VON MARTIUS, *Reise in Brasilien*, I. p. 395.

"Les bouquets de bois dans les *Campos* qui les habitans appellent *capões*. "* * * L'étymologie du mot *capão* est assez jolie. Il vient de *caapoám*, qui, "dans la *lingoa geral*, signifie île."—SAINT HILAIRE, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes*, I. p. 113; II. p. 98.

"The undulating open barren country affords only here and there a few clus-"ters of trees in hollow places; to these isolated woods the name of *Capões* is "given, an appellation which is highly poetical, being derived from the Indian "word *Caapoám*, which signifies an island. These island-woods form a peculiar "feature, in the upland, open, undulating Campos of the province of Minas "Geräes. The trees which compose them, chiefly consist of different species of "*Myrcia*, *Eugenia*, *Vochysia*, *Anona*, *Laurus*, *Styrax*, &c., intermingled with "climbing shrubs, such as *Bauhinia*, *Paullinia*, &c."
GARDNER, *Travels in the interior of Brazil*, p. 431.

‡ The Serra de Piedade is 5400 (English) feet above the sea;
Itàcolumî........ 5710 „ „ ;
Itambè.......... 5965 „ „ .
VON SPIX und VON MARTIUS, *Reise in Brasilien*, I. p. 396; II. pp. 422, 456.

virgin forests; * which are protected by stringent laws.†

The auriferous series consists of granite ‡ and

* Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes*, II. p. 98.

"The *Matos Virgens*, or virgin forests, are such as those which exist on the "Organ Mountains, and indeed along the whole maritime Cordillera. To these "also belong the *Capões* of the *Campo* countries. Next to the virgin forests "come the *Catingas*, the trees of which are generally small and deciduous, and "form the connecting link between the virgin forests and the *Carrascos*, which "grow on more elevated tracts than the *Catingas*, and consist of close growing "shrubs about three or four feet high. These are all natural woods, very different "from * * * the *Capoeiras*, which are wooded tracts formed by the small trees "and shrubs which spring up in lands that have been prepared for cultivation "by destroying the virgin forests, which is generally effected by setting fire to "them; the trees that then spring up are always very distinct from those which "constituted their original vegetation."—GARDNER, *Travels in Brazil*, p. 432.

† "Entre as rossas vizinhas que hoje partem por matto virgem se conserve nas "partilhas, ou extremos huma linda de duzentos palmos de cada parte a qual de "novo senão poderà rossar sem licença do Governo precedendo informaçōes "authenticas se nellas ha arvores de lei que se devão conservar, pois a experi-"encia mostra que a natureza das terras as não produz de novo, ou tarda seculos "para as produzir, e quem sem esta licença rossar as ditas Lindas perderà todo "o dominio e posse que nellas tiver, e ficarà por esse mesmo feito aplicada ao "vizinho com quem parte, que a poderà semear, e desfructar sem que aquelle "que a rossou possa pretender delle causa alguma, alem da pena de cincoenta "oitavas pagas da cadea para o denunciante, e se ambos os vizinhos contravierem "juntamente esta disposição pagarà cada hum a pena em dobro.

* * * * * * *

"Em todas as rossas, terras, sitios, ou vertentes, que se concedessem, ou de "alguma sorte se occupassem depois do dia 30 de Outobro de 1733, ou occupão "em terras de matto virgem, serão obrigados a conservar a decima parte por "rossar da mesma sorte debaixo das mesmas penas que atraz se declarou acerca "das Lindas, ou extremos das demarcaçōes."—*Regimento dos Superintendentes, Guardas-Mores, e Officiaes deputados para as Minas do Ouro. Bando ou Additamento ao Regiminto Mineral*, 13 de Maio de 1736.

Southey, *History of Brazil*, III. pp. 825–6.

‡ At *Gongo Soco* "the Serra which runs from east to west, and lies to the "north of the mine, is of primitive character, the mass of its centre consisting "of granite; upon the granite is imposed a thick bed of schistose and clay "slates, cropping out at an angle of about 45°. Above this lies another thick "bed of ferruginous *Itacolumite*, having the same inclination as the rocks below; "and immediately over this the *Jacotinga*, or soft micaceous iron schist, which "contains the gold, and which is about fifty fathoms in thickness. Above the "*Jacotinga* is another thick layer of *Itacolumite*; and lastly about half a mile

gneiss* overlaid by slates, which — partaking the nature of the rock beneath—are micaceous or talcose as it contains mica or talc. These are at unequal intervals interlaid by thick-flaggy quartz-rocks; which

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"to the south of the mine, a thick bed of a highly crystallized stratified lime-"stone crops out at the same angle, and in the same direction as the other rocks. "About half a mile to the eastward of the entrance to the mine, the bed of "*Jacotinga* narrows to a point, but towards the west it appears to be inexhausti-"ble.—VIRGIL VON HELMREICHEN, *Gardner's Travels in the interior of Brazil*, p. 494.

Henwood, *Edinburgh New Philosophical Journal*, L. p. 61.

* A Monlevade près Santa Barbara "nous avons dans la partie inférieure une "couche puissante d'amphibòle et de feldspath vient ensuite le gneiss, puis après "le schiste talqueux et micacé, parsemé de veines de quartz, puis le grès élas-"tique, sur lequel repose une couche de *Jacutinga* et de fer oxydulé (le plus "riche), qui a plus de 50 pieds d'epaisseur; puis du grès, puis d'autres couches "de fer, &c."—M JEAN ANTOINE DE MONLEVADE, MSS.

von Spix und von Martius, *Reise in Brasilien*, I. p. 352. von Eschwege, *Annales des Mines*, VIII. pp. 401-430; *Pluto Brasiliensis*, p. 210.

"The Morro da Villa Rica consists almost entirely of a primary quartz-slate, "resting on gneiss and mica-slate. Occasionally clay-slate intervenes between "the gneiss and quartz-slate, and sometimes the mica-slate is entirely wanting. "* * * The quartz-slate puts on a variety of aspects. Very low down it con-"tains a large portion of mica and the grains of silex are more regular. * * * "Higher up in the mountain it partakes more the character of a simple rock; "being tolerably compact, granular, and stained in spots with iron. The grains "are occasionally as large as small peas, and enveloped in a finer matter. This "formation is intersected by veins and nests of quartz, which do not seem to "have in any way disturbed the stratification of the rock. Contrary to what is "generally remarked of quartz-rock, this formation is eminently metalliferous, "and the numerous holes and excavations made in the veins of quartz have "been rewarded by the discovery of large quantities of gold. * * *

"About two hundred feet up the mountain large masses of talc-slate are em-"bedded, and frequently cover the rock just described. This slate is of a "whitish or lead colour; and immediately in contact with it, another rock, "which I have named a ferro-micaceous slate, is generally seen to rest. Some-"times this slate has only a very slight tinge of iron; at other times it exists "perfectly decomposed, and puts on the appearance of decayed wood. Fre-"quently the mica appears completely lost; and the slate takes the character of "micaceous iron, and is essentially an ore, and worked as such. When it "assumes this form, a blow with a hammer on the strata causes a quantity of "fine sand to issue from between the laminæ. In some spots one or other "of these beds is often wanting."

CALDCLEUGH, *Travels in South America*, II. pp, 259-261.

are likewise micaceous in some places but talcose in others.* Clay-slate, which passes at times into chlorite-slate, succeeds the mica and talc slates, and includes also large masses of quartz. In many parts of the next formation granular quartz, mixed occasionally with a small proportion of lime, is interlaminated with mica or talc; † but in others these are replaced by thin bands of specular ‡ or oxydulated iron-ore.

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* "Les lamelles de talc ou de chlorite se joignent si bien les unes avec les "autres, en entourant les graines de quartz, que la roche devient souple; c'est "ce que l'on a appelé grès flexible ou élastique du Brésil."

von Eschwege, *Annales des Mines*, viii. p. 411.

Mawe, *Annales des Mines*, iv. p. 234. von Spix und von Martius, *Reise in Brasilien*, i. p. 352. Caldcleugh, *Travels in the interior of Brazil*, ii. p. 260. Claussen, *Bulletins de l'Académie Royale des Sciences de Bruxelles*, viii. (1re partie) p. 325.

† "L'itacolumite est de même âge que le thonschiefer primitif, le schiste "ferrugineux, le talc, la chlorite schisteuse, l'itabirite et le calcaire primitif. "* * * Les parties essentielles de cette roche son le quartz et le talc, ou la "chlorite. Le tissue est schisteux, à grains gros, moyens ou petits, suivant "que le talc ou la chlorite domine et s'y trouve en lamelles comme le mica dans "le mica-schiste." von Eschwege, *Annales des Mines*, viii. pp. 410–411; *Pluto Brasiliensis*, p. 218.

von Spix und von Martius *Reise in Brasilien*, i. p. 353. Caldcleugh, *Travels in the interior of Brazil*, ii. p. 260. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. (1re partie) p. 325. von Helmreichen, *Gardner's Travels in the interior of Brazil*, p. 498. Murchison, *Geology of Russia in Europe and the Ural Mountains*, i. pp. 381, 481. Henwood, *Edinburgh New Philosophical Journal*, l. p. 61.

‡ "*Itabirite.* Du fer oligiste micacê *(eisenglimmer)*, du fer oligiste en général "compacte plus rarement feuilleté, un peu de fer oxidulé et de quartz disséminés, "composent cette roche, qui est tantôt solide et compacte, tantôt d'une texture "grenue-schisteuse. * * * Toutes ces masses sont magnétiques et même "magnêtipolaires. * * * Ce nom est dérivé de celui du pic *d'Itabira*, non loin "*de Sabarà*."—von Eschwege, *Annales des Mines*, viii. pp. 417–419; *Pluto Brasiliensis*, p. 222.

De Monlevade, *Annales des Mines*, iv. p. 137. von Spix und von Martius, *Reise in Brasilien*, i. p. 404. Caldcleugh, *Travels in the interior of Brazil*, ii. p. 261. J. C. Hocheder, *Reports of the Imperial Brazilian Mining Association*, xv. (1833) p. 54. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. (1re partie) p. 327. von Helmreichen, *Gardner's Travels in the interior of Brazil*, p. 494. Henwood, *Edinburgh New Philosophical Journal*, l. p. 61.

Sometimes, however, the iron-ores—slightly mixed with other ingredients—form beds of enormous thickness.* Hornblendic rocks† potstone,‡ and dolomite§ occur amongst the upper slates.

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* "The constituent parts of the *Jacotinga* are iron-mica and quartz; the latter "usually in a state of disintegration. * * * Manganese, scaly talc, and massive "iron glance are its chief accidental ingredients; and of these the first occurs "in layers from one quarter of an inch to two or three inches in thickness; "whilst the other two are embedded in irregular strings and nests.

J. C. HOCHEDER, *Reports of the Brazilian Mining Association*, XV. (1833) p. 54.

von Eschwege, *Annales des Mines*, VIII. p. 417. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. (1re partie) p. 327. von Helmreichen, *Gardner's Travels in the interior of Brazil*, p. 494. Henwood, *Edinburgh New Philosophical Journal*, I. p. 61.

† "Un fait remarquable est le passage de le thonschiefer au grünstein, qui y "forme des nids. On trouve d'abord du feldspath et de l'amphibole disséminés "cà et là dans la masse. Ces parties prennent peu à-peu de la consistence, "dominent et finissent par former une masse solid de grünstein enveloppée "comme un noyau dans la roche."

von Eschwege *Annales des Mines*, VIII. p. 416; *Pluto Brasiliensis*, p. 215.

‡ "Les couches talqueuses, liées ae thonschiefer, offrent un champ plus riche "aux minéralogistes. Le talc, la chlorite schisteuse et la pierre ollaire, minéraux "entre lesquels il est difficile de tracer une ligne de démarcation, se trouvent "quelquefois séparés les uns des autres; cependant la chlorite schisteuse et la "pierre ollaire sont presque toujours ensemble."

VON ESCHWEGE, *Annales des Mines*, VIII. 416.

Claussen, *Bulletins de l'Académie Royale des Bruxelles*, VIII. (1re partie) pp. 324-326.

Near Cäethé and Brumado culinary vessels *(panelas)* are made of potstone.

§ "Le terrain calcareux de transition est composé de couches à peu près "horizontales de phyllades argileux, pétrosiliceux et macignos. Elles contien- "nent, spécialement dans leurs assises inférieures, des couches puissantes de "calcaire noir et gris." CLAUSSEN, *Bulletins de l'Académie Royale de Bruxelles*, VIII. (1re partie) p. 328.

von Helmreichen, *Gardner's Travels in Brazil*, p. 494. Henwood, *Edinburgh New Philosophical Journal*, L. p. 61.

The limestone largely quarried between *Gongo Soco* and Sorocco contains—

Carbonate of lime........	59·7	per cent.
Carbonate of magnesia....	35·6	,,
Peroxide of iron	3·2	,,
Silica	0·5	,,
Alumina..................	0·2	,,
	99·2	

FARADAY, *Reports of the Imperial Brazilian Mining Association*, V. (1828) p. 90.

All parts of the series yield more or less gold; but the riches of each separate member are confined to deposits peculiar to it alone; for within the whole region there is not a single vein, dyke, or other metalliferous repository whatever common to, even two, contiguous strata.* So short, scattered, and irregular, indeed, are the productive portions, that adjoining mines, in the same rock formation, are seldom or never on the same continuous auriferous mass.

(A.) Granite rises to considerable elevations in many places,† but it forms none of the highest peaks.

Granite composed of quartz, yellowish buff-coloured mica, and white felspar, in an advanced stage of decomposition, appears about a mile east of Caethé.

Enormous blocks, fallen from the higher peaks of granite, in which smallish crystals of felspar are scattered through a basis of quartz, felspar, and mica, overspread the eastern slopes of the Serra de Caraça.‡

Crystallized quartz, enclosing crystals of schorl,§ is mixed with lemon-coloured talc, lithomarge, felspar,

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* Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. (1re partie) pp. 323, 324.

† von Spix und von Martius. *Reise in Brasilien*, I. pp. 360—9. Gardner, *Reports of the Imperial Brazilian Mining Association*, I. (1826) p. 71. von Helmreichen, *Gardner's Travels in the interior of Brazil*, p. 494. Henwood, *Edin. New Philosophical Journal*, L. p. 61.

‡ von Eschwege, *Annales des Mines*, VIII. p. 413. von Spix und von Martius, *Reise in Brasilien*, I. pp, 403–8. Auguste de Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes*, I. p. 215. Gardner, *Travels in the interior of Brazil*, p. 505.

§ Certain sands of the Paraöpéba,—derived, perhaps, from granite in the neighbourhood,—contain schorl; which has often been mistaken for tin-ore. Amongst the oxydulated iron-ore with which it is mixed Messrs. von Spix and von Martius (*Reise in Brasilien*, I. p. 320) found both chromium and manganese.

and, in some spots, with earthy brown iron-ore also at Turvo near the Periçicába.

(I.) Granules of gold are sparingly mixed with quartz, felspar, and oxydulated iron-ore,* in the granite of *Candonga*; just as tin-ore † is sprinkled through that of Cornwall.

(*a*.) Although the metalliferous deposits are more quartzose, and contain a larger proportion of iron-ore, than the rock, they partake its granitic character. Through this ferruginous granite, gold is always thinly scattered,‡ alloyed, however, with from five to eight per cent. of palladium,§ and of a yellow as pale as that assumed occasionally by native silver,|| it forms

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* "Le granite de ce pays contient beaucoup de fer oxydulé, accidentellement "mélangé."—Von Eschwege, *Annales des Mines*, viii. p. 407.

"In Baiern kommt in mehrenen Gegenden, z. B. am Fichtelberg und zu Floss "granit vor, in velchem der Eisenglimmer die Stelle des gemeinen Glimmers "vertritt."—von Spix und von Martius, *Reise in Brasilien*, i. p. 351.

† "Three miles south-east of Two-bridges" on Dartmoor "where some tin-"mines are worked, that metal is found disseminated in the granite, as one of "its integrant parts."—Berger, *Geological Transactions*, i. p. 120.

"Small crystalline granules of tin-ore are dispersed through and form an "integral part of the granite, at *Balleswidden*, Raggy-rowal, *Wheal Vyvyan*, "*Carclaze*, Kit-Hill, &c."—*Cornwall Geol. Trans.* v. pp. 15, 53, 73, 119, 235.

‡ Captain Herbert, *Asiatic Researches*, i. (1829) p. 236. *Ante*, pp. 3, 46, Notes.

"The auriferous sand at Peshanka seemed to be simply the disintegrated "surface of the subjacent rock, a sort of syenite or 'granite pourrie.'"
Murchison, De Verneuil, & von Keyserling, *Geology of Russia in Europe and the Ural Mountains*, i. (1845) p. 483.

"Professor Hoffman has ascertained, that in a considerable region of eastern "Siberia, the gold *is really disseminated*, not only through granite and other "igneous rocks, but also through large bodies of clay-slate."—*Ibid*, p. 483.

In Australia "gold is visible in the decomposing exfoliative surfaces of granitic "boulders" amongst the "alluvia of the Uralla."
Clarke, *Quarterly Journal of the Geological Society*, xi. (1855) p. 403.

"In the eastern gold-fields" of Australia "gold is found in the granite."
Selwyn, *Quarterly Journal of the Geological Society*, xiv. (1858) p. 536.

§ Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., &c., MSS. Cock, *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, xxiii. (1843) p. 16.

|| Levy, *Description d'une collection de Minéraux, formée par M. Henri Heuland*, ii. pp. 320—8.

sometimes a model sometimes a mould for other minerals; and thus embeds in some places the same ingredients which embed it in others.* Gold, in rough crystals,† often studs the sides of drusy cavities; and in minute spheroids, seldom more than from 0·012 to 0·022 of an inch in diameter, it is sometimes scantily disseminated through other parts of the formations.

Their more quartzose portions enclose nests of earthy brown iron-ore, and small octahedral crystals of pure bright-yellow gold.‡

Microscopic double-pointed crystals of quartz,§ meanwhile, sprinkle every crevice.

(*b.*) The auriferous repositories are bounded by joints of one series; but barren matter within joints of different range sometimes interrupt them;|| in both, however,—as in the adjoining rocks—the prevalent ingredients are granitic.¶

(II.) (*a.*) The granite of the Caraça—neither traversed by auriferous veins nor charged with gold—is overlaid at *Santa Rita* by thick lamellar joints which—bearing

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* Carne, *Cornwall Geol. Trans.*, IV. p. 100.

† Mohs, *Mineralogy* (translated by Haidinger), II. p. 437. Levy, *Description d'une collection de Minéraux*, II. p. 313.

‡ Edward W. Lott, Esq., Commissioner of *Candonga* (1844), MSS.

§ Henwood, *Cornwall Geol. Trans.* v. p. 215. Table C.; *London, Edinburgh, and Dublin Phil. Magazine*, 3rd Series, XXIX. (1846) p. 359; *Gangstudien*, II. (Freiberg, 1851) pp. 116–120. Breithaupt, *Gangstudien*, II. pp. 120–1. *Lond., Edin., and Dublin Phil. Mag.*, 4th Series, v. p. 228. Gümbel, *Gangstudien*, II. p. 120. *London, Edin., and Dublin Phil. Mag.*, 4th Series, v. p. 228. Tröger, *Gangstudien*, II. pp. 216–253. Dufrénoy, *Annales des Mines*, 4me Série, XVI. p. 118.

|| H. V. von Helmreichen (1844) MSS.

¶ *Cornwall Geol. Trans.* v. *Tables XIII. XVI. XLIII. L. XC.*

nearly north and south* and dipping 18°–30° east—are for the most part composed of quartz cemented by a buff-coloured, brittle, scaly mineral, differing in some respects from either mica or talc, but possessing certain characters common to both.† Its texture is in general tolerably uniform; but thin layers of felspar-clay appear in some places, and short narrow beds of quartz with earthy brown iron-ore occur in others, Minute octahedral crystals of oxydulated iron-ore are numerous, and microscopic particles of gold form 0·0000008 to 0·0000055 of the mass.‡

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* In Minas Geraës, during 1845, the easterly magnetic variation was less than one degree.—von Helmreichen, MSS.

Sabine, *Phil. Trans.*, cxxxix. (1849), Pl. xv.

† von Eschwege, *Annales des Mines*, viii. pp. 410, 411. von Spix und von Martius, *Reise in Brasilien,* i. pp. 352–3; English Translation, ii. pp. 202–3. Mohs, *Mineralogy* (translated by Haidinger), ii. pp. 195–6.

‡ Johnson, *Report of the Imperial Brazilian Mining Association* (li.), Nov. 1851.

"The only work" in the Ural "at which subterranean mining in the solid "rock is still practised, and at a very small profit, is at Berezovsk near Ekaterin-"burg. The chief fundamental rocks are talcose, chloritic schists, and clay-"slates * * * and these have been cut through by parallel bands of a felspathic "rock called 'beresite,' which M. Rose considers to be a decomposed granite. "* * * The band of 'beresite' which bears in truth, the aspect of a metal-"liferous lode, trends from north to south, and contains within it many veins of "quartz, in which the gold occurs, and from which it is extracted both by verti-"cal shafts and lateral galleries which have been made in the masses of the "'beresite.' On each flank of the lode, the talc schist in contact with the "'beresite' is a reddish decomposing altered rock, called 'crassick' by the work-"men. In some parts of the works the quartz veins so multiply as almost to "exclude the 'beresite,' whilst some other or poorer veins traverse the mass "diagonally and even from west to east. In contact with the quartz veins the "'beresite' is usually compact and hard, but at a little distance from them, that "substance is usually in a form which would convey to the ordinary observer "merely the idea of kaolin or decomposed felspar rock. No shaft has been sunk "lower than twenty-eight fathoms, but the works, * * * at the period of our "visit, were only carried on at a level of sixteen fathoms.

"From the year 1745, to the time of our visit, 1841, these mines had afforded "52,000,000 poods" (1,878,500,000 lbs. avoirdupois) "of ore-stuff which had

(*b*) Near Caëthé the granite is succeeded by fine-grained greyish-buff schistose rocks, composed chiefly of quartz and either mica or talc, but mixed with small quantities of felspar also; which are surmounted by mottled white and red clay-slate. Trending, like the surface, in some places N.E. and S.W., in others S.E. and N.W., they always dip hillward to the south. The granite and clay-slate are destitute alike of veins and of gold; but at *Rossa Grande** the talco-micaceous slates—enclosing, at intervals, nests and short, thin, conformable beds of either mica or talc and quartz †—are slightly auriferous.

(*c*.) An irregularly ramified mass of quartz (*Fig*. 12) wrought to a depth of more than 120 fms. in fine-grained quartzose talco-micaceous slate ‡ (Itacolumite §) at

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" yielded 679 poods " (24528·875 lbs. avoirdupois or 0·000013 its weight) " of " gold.

" The Russian pood, or 40 lbs. of that country, is equal to 36 lbs. 2 oz. English " avoirdupois."

Murchison, de Verneuil, & von Keyserling, *Russia in Europe and the Ural Mountains*, I. pp. 476-7. *Siluria* (3rd edit., 1859), p. 481.

* Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. 1re partie (1841), p. 324.

† *Ante*, p. 10.

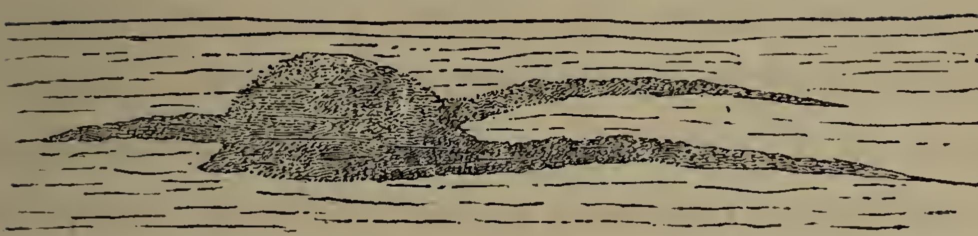
‡ Mawe, *Travels in the interior of Brazil*, p. 307. *Annales des Mines*, II. (1817) p. 234. von Spix und von Martius, *Reise in Brasilien*, I, p, 353; English Translation, II. p. 263. von Eschwege, *Annales des Mines*, VIII. (1823) pp. 407–415. *Pluto Brasiliensis*, p. 218. Caldcleugh, *Travels in South America*, II. pp. 259-61. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. 1re partie (1841), pp. 323-326. von Helmreichen, *Gardner's Travels in the interior of Brazil*, p. 494. Murchison, de Verneuil & von Keyserling, *Geology of Russia*, I. pp. 381, 481. Henwood, *Edinburgh New Philosophical Journal*, L. (1850) p. 61.

" Quarzschiefers zwischen den Grasflächen hervor. Besonders zeichnet sich eine

§ " Der *Itacolumi*, ist die höchste Kuppe der Serra de Oiro Preto " * * *, " Gegen die Spitze hin treten mächtige Felsenblöcke und Riffe des weisslichen " ungeheuere Felsenmasse aus, welche von dem Gipfel losgetrennt, unterhalb " demselben etwas schief herabhängt, und von Villa Rica aus deutlich geschen " wird." * * * " Dieser Felsen, gleichsam der Sohn des Hauptgipfels, hat die

Fig. 12.

CATTA BRANCA. *Plan.*



*Catta Branca,** afforded much gold, beside the sulphurets of bismuth and antimony in smaller quantities. The produce was,†—

Date.	Vein-stone. Tons (avoirdupois).	Gold. lbs. (Troy).	Proportion of gold in the mass.
1840	18,230·	974·	0·0000196
1841	21,704·	864·	0·0000146
1842	21,612·	790·	0·0000134
1843	21,648·	385·	0·0000065
1844 (6 months)	7,900·	154·	0·0000071 ‡
Total..	91,094·	3,167·	mean 0·0000128

As the mine was deepened, the quartz contained a gradually smaller proportion of gold.§

" indianische Benennung von *Ita* (Stein) und *Columi* (kleiner Sohn) veranlasst."
VON SPIX und VON MARTIUS, *Reise in Brasilien,* I. p. 395–6.
English Translation, I. p. 268. Eschwege, *Pluto Brasiliensis,* p. 221. Saint Hilaire, *Voyage dans le District des Diamans et sur le Littoral du Bresil,* I. (1833) p. 186. Walsh, *Notices of Brazil,* II. p, 193. Henwood, *Edinburgh New Phil. Journal,* L. p. 61.

* Claussen, *Bulletins de l'Académie Royale de Bruxelles,* VIII. 1re partie (1841), p. 326.

During one of the thunder-storms which ushered the rains in 1842, several electrical discharges—conducted by the *whim-chains* to a depth of one hundred and twenty fathoms in *Catta Branca*—partially paralyzed some of the workmen.
CAPTAIN WILLIAM WILLIAMS (Manager of *Catta Branca),* MSS.

Like occurrences at *Beschert Glück* in Saxony and at *East Wheal Crofty* in Cornwall are described by Daubuisson, *Des Mines de Freiberg en Saxe,* III. p. 150; and by me, *Cornwall Geol. Trans.,* V. p. 457*.

† Mining Journal.

‡ As mines are carefully stripped before they are abandoned, their last is not always their poorest produce.

§ " In Victoria thousands of pounds were expended on lodes that had been

(*d, e.*) The mines of *Paciencia* and *Coelho* near São Vicente afford minute particles of gold, sparingly mixed with tellurium,* the sulphuret of antimony,† and iron pyrites, in a broad band of quartz; which—bearing east and west—conforms to the structure, and partakes the character of the adjoining talcose slate.

(*f.*) The talcose slate which, in a range subordinate to the Caraça, yields gold at *Santa Rita*,‡ is succeeded by quartz-rocks; and these—themselves slightly, if at all, metalliferous—are traversed by auriferous veins of quartz at *Catta Preta*.§

The rocks,—generally of pale-buff or dark-red colour, varied texture, and granular structure,—are everywhere traversed by two series of joints which range from N.E. to S.W. and S.E. to N.W., respectively.

" rich at the surface, in the expectation that as rich or richer deposits would be " met with at a greater depth. In nearly every instance the adventurers met " with disappointment. Instances are innumerable of veins of quartz, highly " auriferous in their upper parts, containing none of the precious metal below."
Belt, *Mineral Veins, an enquiry into their origin, founded on a study of the auriferous quartz veins in Australia*, London, 1861, 8vo. pp. 1-52.

* Henwood, *Cornwall Geol. Trans.*, vii. p. 228.

† Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. 1re partie (1841), p. 326.

‡ *Ante*, p. 176.

§ " Unmittelbar am Fusse der *Serra do Caraça* (in *Cata Preta*) * * * das " Metalls aus Steinen durch Pochen gewonnen, wegen seiner graugelben Farbe " merkwürdig, bei zweckmässiger Einschmelzung bis zu drei und zwanzig Karat " gereiniget werden kann."—von Spix und von Martius, *Reise in Brasilien*, i. p. 408; English Translation, ii. p. 287.

von Eschwege, *Pluto Brasiliensis*, p. 295. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. 1re partie (1841), p. 327. Gardner, *Report of the Imperial Brazilian Mining Association*, i. (1826) p. 69. Edwards, *Ibid*, p. 73. Tregoning & Bray, *Ibid*, xx. (1836) p. 45. Pengilly, *Ibid*, xxxvi. (1834), p. 1. Henwood, Blamey, Pengilly, & Luke, *Ibid*, xxxvii. (1844) p. 3. Henwood, *Ibid*, xxxviii. (1845) p. 4; xli. (1846) p. 9.

Vein-like masses having both these directions yield gold; but in different parts of the mine.

From north-east to south-west ancient works * of great extent follow the course of a metalliferous deposit; which—oblique both in strike and dip to the beds of quartz-rock, yet parallel to one series of its joints—dips hillward, 40°–58° towards the south-east. Its chief ingredient,—transparent, colourless crystalline quartz,—is traversed in all directions by innumerable minute cracks and fissures; which are, in some places, lined with thin scales of compact red iron-ore; such portions often contain particles of very bright gold. Its wider parts sometimes enclose isolated masses of granular quartz-rock.

The same formation—traced great part of a mile and uniting with several floors (*Fig.* 13, *c*, *c*) towards

Fig. 13.

CATTA PRETA. *Transverse section.*

a Quartz-rock. *b* Gold formation. *c* Floors.

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* From the roofs of these openings hang tufts of dry grass and dead fern in which humming-birds often build. In one of these, six nests, resting one on another, contained the *exuviæ* of successive broods. But coarse stems pendant from the thatched roofs of *whim-houses* at *Gongo Soco* were their favourite resting-places; and there, regardless of men and horses, they built, and reared their young. During spring the humming wings of those exquisite creatures were plainly heard, as—flashing between the leaves which shaded my veranda—they fed from flowers within a few feet of my head. A large, long-tailed, black species,—the only one which seems a permanent inhabitant of Minas Geraës,—may be often heard in song on the thickets *(Capoes)* near Cattas Altas.

the north-east—has been followed to a depth of eighteen fathoms * near the mansion at *Catta Preta;* where—averaging two or three, but in some places as much as twenty, feet wide—its ingredients—much the same as before—afford 0·0000132 their weight of gold.

(III.) (*a.*) The clay-slate which northward passes by degrees into talc-slate at *Rossa Grande*† forms southward the Serra do Tijuco (Luiz Soares). Its planes of cleavage range from east to west, and—sometimes slightly contorted—dip 30°–40° south. Of either a white,‡ buff, red, or brownish tint in different places, it is interlaid, near the ridge of the mountain, by a broad band of leaden hue; in which round, spheroidal, and angular masses of smoke-coloured quartz cemented by milk-white or colourless quartz form subordinate layers; these are—as at *Catta Preta* §—traversed in all directions by minute cracks || and flaws without number. But, though the quartz is auriferous and many of its joints—filled with talc—are faced with gold; the formation, in general, is poor.

(*b.*) At the *Camara*, north-east of *Gongo Soco, (Pl. IV., Figs.* 1, 2, 3), repeated trials have been made in the clay-slate of this range. Exhibiting occasional

* Henwood, *Report of the Imperial Brazilian Mining Assoc.*, XLIII, (1847) p. 6.

† *Ante*, p. 178.

‡ "A league frem Caeté I visited a gold mine * * * in which the gangue was "quartz traversing chlorite slate, which afterwards lost its colour and became "talc."—Caldcleugh, *Travels in South America*, II. p. 279.

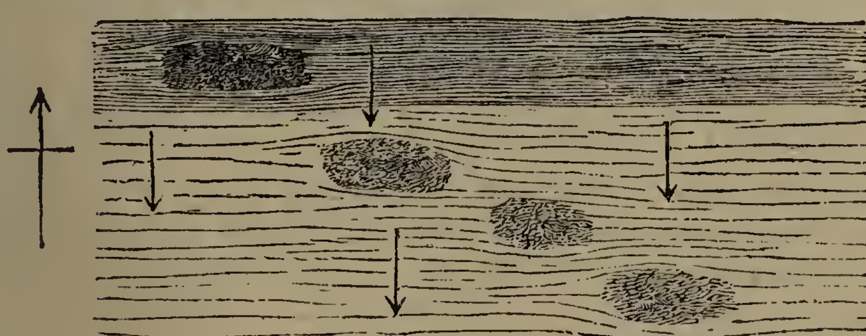
§ *Ante*, p. 181.

|| "Cette roche contient des nids (appelés par les mineurs *panellas)*, et des "petites veines d'une matière blanche, argileuse et talqueuse (lithomarge ?), "dans lesquelles se trouvent enveloppés pêle-mêle des cristaux pour la plupart "brisés de quartz."—Claussen, *Bulletins de l'Académie Royale, des Sciences de Bruxelles*, VIII. 1re partie (1841), p. 326.

flexures, yet on the whole bearing nearly east and west and dipping south,—the lower portions are of uniform texture and brownish hue, whilst the upper parts present blue and homogeneous, alternating with yellowish-white, siliceous laminæ.

Quartz and earthy brown iron-ore *(gossan)* are thinly spotted with gold of the finest quality in many isolated beds, which—from a mere line to perhaps three feet wide, and from a few feet to eight or ten fathoms long—occur throughout the formation and accommodate themselves to all its undulations. Some of these gradually assimilate to the rock, others end abruptly * at its joints; generally, however, they re-appear on other, but parallel, lines of *strike* towards the *right-hand* † (*Fig.* 14).

Fig. 14. GONGO SOCO,—CAMARA. *Plan.*



* "In one part of their course all the *lodes* of *Dowgas* terminate abruptly; "they are however rediscovered at a distance of about four fathoms towards the "right, at nearly right angles."

HENWOOD, *Cornwall Geol. Trans*, v. *Table LXXXIV.*

† "*Heaves* are generally described as towards the *right* or *left hand*, because "the same expression serves on approaching the intersecting vein on either side; "if the terms north and south be used, it must also be said whether it is ap-"proached from the east or west."

THOMAS, *Survey of the Mining District between Chacewater and Camborne* (London, 1819), p. 22, *Note.*

(*c*.) The homogeneous greyish-blue slate of *Ouro Fino*, near Palmital, is interlaid by a bed of quartzose slate from two to eight feet in thickness, containing reniform pieces of slate,* mixed with globular and spheroidal masses of white iron pyrites, which—as well of radiated and fibrous as of concentric lamellar structure†—affords 0·000014 its weight of gold.‡

(*d*.) For more than a century before *Morro Velho* § was purchased by the Saint John d'el Rey Company,

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* Mr. Carne, *Phil. Trans.*, XCVIII. (1807), p. 293; *Cornwall Geol. Trans.*, II. p. 94. Henwood, *Ibid*, V. pp. 36, 72, 157, 183; *Tables XXXIV., LVIII.* Mr. Salmon, *Quarterly Jour. of the Geological Society*, XVII. p. 517.

† *Cornwall Geol. Trans.*, V. *Table VI.* p. 183.

‡ John George Goodair, Esq. (sometime proprietor of *Ouro Fino)*, MSS.

§ In 1814, the mine of *Morro Velho*, belonging to Donna Anna Correira da Silva—wrought by .. 24 freemen and
122 slaves,—
yielded (4,533 *oitavas*) 43 lbs. 6 oz. 10 dwts. 10 grains of gold.

von Eschwege, *Pluto Brasiliensis. Tabellarische Uebersicht aller Goldlavaras jeden Districts in der Provinz Minas Geraes* (1833), XVI.

At *Morro Velho* "the gold works of Padre Freitas are situate in an immense "*quebrada* or ravine, which has been worked almost through the heart of a "mountain of chlorite slate, intersected by quartz veins, in which the gold exists "in combination with arsenical and iron pyrites. The chlorite slate, which is "highly inclined, also contains gold in proximity to the veins, and, as well as "the quartz veins, is stamped. The walls of the mine are encrusted with white "acicular crystals of sulphate of alumine. * * * The ore is pounded by two "stamping mills before it arrives at a third and last. The larger blocks are split "by means of gunpowder, but if that article is scarce, they are heated by fire, "and water is then thrown over them. The daily produce is never less than 25 "*oitavas* (2 oz. 17 dwts. 15¼ grains) and it generally exceeds 30 *oitavas* (3 oz. "9 dwts. 4 grains). The expenses are calculated at 1½ *oitavas* (3½ dwts.) of gold "per week for each slave employed. The gold seldom exceeds nineteen carats in "fineness. The mine had been constantly worked since the year 1725, and his "father had bought it for 120 *cruzados* (£19 : 12 : 10), which it soon repaid."

Caldcleugh, *Travels in South America* (1825), II. pp. 271-4.

"Der dicht mit Gersträuch bewachsene Berg läuft von Nord nach Süd und "besteht aus demselben grünlichgraun, violetten und röthlichen Thonschiefer, "wie das Ufer des *Rio das Velhas* bei *Santa Rita*. In ihm streichen meistens "von N.O. nach S.W. Gänge eines grauen dichten Quarzes, der neben vielem "Schwefel-und Kupferkies auch Gold enthält. Hie und da wittert aus dem

and had become in their hands the largest, deepest, and most productive gold-mine in the world, it was worked by successive native proprietors with varied results.

(1.) The rock is clay-slate, of uniform texture, thick-lamellar structure, and, mostly, leaden hue; but in some spots it is deep brown; and a few thin laminæ—which, perhaps, contain chlorite—are dark green. Certain quartzose portions are crystalline; and at one hundred and thirty or one hundred and forty fathoms

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"Gestein ein Gemische von Alaun und schwefelsaurem Kupfer unter der Form "eines weisslichgrauen Pulvers aus. Die sogenannte Mine besteht in Gruben "und Löchern, aus denen das goldreiche Material durch Sprengen und durch den "Hammer gewonnen und von den Negern in Pochwerke hinabgebracht wird. "* * * Das Gold der Mine des Padre Freitas hat wie das der benachbarten "*Lavaras* von *Congonhas* und *Itaubira* wegen Beimengung anderer Metalle nur "neunzehn *Quilates;* die Mine entschädigt aber den Eigner durch den Reich-"thum der Erze, und gehört zu den ergiebigsten in der Provinz, denn sie soll in "der letzten Zeit jährlich funfzigtausend Cruzados" (£6,597 : 18 : 4) "abge-"worfen haben."

von Spix und von Martius, *Reise in Brasilien* (1828), II. pp. 417–18.

"Congonhas doit sa fondation à des mineurs attirés par l'or que l'on trouvait "dans les alentours, et son histoire est celle de tant d'autres bourgades. Le "précieux métal s'est épuisé; les travaux sont devenus plus difficiles, et Con-"gonhas n'annonce actuellement que la décadence et l'abandon."

Saint Hilaire, *Voyage dans le district des Diamans et sur le littoral du Brésil* (1833), I. p. 169.

"The mine of Morro Velho * * * had been worked by its proprietors for "about a hundred years previously to its being bought by the present Company "* * * which first commenced operations about 1830, under superintendence of "Captain Lyon, the northern voyager. * * * The auriferous vein occurs in a "grayish coloured slate; the vein, or *lode* itself, consisting of a kind of quartzose "rock mixed with a considerable proportion of carbonate of lime, strongly im-"pregnated with iron, arsenical, and copper pyrites; its general direction is "from east to west, and it is about seven fathoms wide a little to the west of "the central workings, at which point it divides into two branches that run to "the westward, while other two extend to the eastward; the more easterly "branches are those that have been worked to the greatest extent. These rami-"fications gradually diverge, and ultimately take a N.E. direction, running "parallel to each other, at a distance of about a hundred feet."

Gardner, *Travels in Brazil* (1846), p. 496.

deep, they become highly pyritic.* Within short distances of the *(lode)* auriferous deposit the slate also contains gold,† but seldom or never in quantities‡ sufficient to defray the cost of extraction.

The laminæ bear generally N.E. and S.W., and dip S.E. 40°–70°; § but they are much curved in some parts of the mine, and greatly contorted in others.||

Three series of joints, bearing respectively about

E. and W.,;¶—
40° S. of E. and N. of W.;**—and
N. and S.;¶—

traverse the whole formation; but they are not alike

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* Captain Treloar, *Reports of the Saint John d'el Rey Company*, xxix. (1858) p. 28.

† Henwood, *Cornwall Geol. Trans.*, vi. (1844) p. 145; *London, Edinburgh, & Dublin Phil. Mag.*, 3rd Series, xxv. (1844) p. 343.

‡ "Resting on the *north branch* in the *Bahú* there are about 13,000 tons of "*killas*, worth perhaps only about" (0·0000034 its weight) "one *oitava*" (55·33 grains) "of gold per ton."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, xx. (1849) p. 13.

"That portion of the ore which we call *Black or dead Killas* we find will yield "only" (0·00000212 its weight) "six-tenths of an *oitava*" (33·199 grains) "of gold per ton."—Messrs. Walker & Reay, *Ibid*, xxiv. (1853) p. 43.

"651·2 tons of Killas yielded" (55·099) oz. Troy) "478 *oitavas*" (0·00000249 its weight) "of gold."—Mr. Symons, *Ibid*, xxviii, (1857) p. 47.

"442·8 tons of Killas yielded" (19·942 oz. Troy) "173 *oitavas*" (0·00000143 its weight) "of gold.
"272·8 „ „ (23·515 „) "204 *oitavas*" (0·00000264 its weight) "of gold."
Ibid xxxi. (1860) pp. 45–8.

§ Henwood, *Cornwall Geol. Trans.* vi. (1844) p. 143; *London, Edinburgh, & Dublin Phil. Mag.*, 3rd Series, xxv. (1844) p. 341.

"The cleavage planes bear about north 36° east, and dip about south 53° east, "at angles bearing from 44° to 70°."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, xxvii. (1856) p. 26.

|| *Ibid*, p. 27.

¶ Henwood, *Cornwall Geol. Trans.* vi. (1844) p. 143.

** Capt. Treloar, *Reports of the Saint John d'el Rey Company*, xxvii. (1856) p. 26.

numerous in all parts of it. Some members of each series maintain their slightly undulating courses without interruption for considerable distances; others—appearing at intervals—are so short, that it is difficult, if not indeed impossible, to classify them; whilst great numbers,—of which there had been no previous trace,—appear when the rock is broken.*

(2.) In position the metalliferous deposit coincides, sometimes with the laminæ, sometimes with the joints† which traverse them; ‡ and thus—presenting many sudden, and apparently capricious, flexures—it assumes the character, of a bed in some places, but of a vein *(lode)* in others; §—its contour, however, resembles, in some measure, that of the mountain ‖ wherein it is so largely and successfully wrought. Different names

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* Dr. Boase, *Cornwall Geol. Trans.*, IV. (1832) p. 499. Mr. Enys, *London & Edinburgh Phil. Mag.* N.S. II. 1833, p. 322.

† "At the *West Quebra Panella*, throughout the *Bahù* mine, and in the *West* "and *Middle Cachoeira* the main body of the metalliferous mass traverses the "lines of lamination in the containing rock, but at the *East Cachoeira* it curves "so rapidly towards the north, that at its eastern extremity it runs almost paral- "lel with the lines of lamination."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, XX. 1849, p. 7; *Ibid*, XXVIII. 1857, p. 28,

‡ "The large veins often correspond with the *seams* of the layers of rocks, and "the smaller ones with those of the component blocks and laminæ of these "layers."—Dr. Boase, *Cornwall Geol. Trans.*, IV. 1831, p. 448.

§ "Veins cross the strata and have a direction different from them * * * beds "have, on the contrary, a similar direction to the strata of the rock; and, instead "of crossing, run parallel to them."—Werner, *New Theory of the formation of Veins* (Anderson's Translation), p. 3.

"Sometimes the same vein intersects in one place those strata to which it is "parallel in another. In such cases it becomes sometimes difficult to distinguish "between a vein and a stratum."

Dr. Macculloch, *Classification of Rocks*, p. 115.

Mr. Taylor, *Reports of the British Association*, 1833, p. 2.

‖ Henwood, *Cornwall Geol. Trans.*, VI. 1844, p. 143; *London, Edinburgh, & Dublin Phil. Mag.*, 3rd Series, XXV. 1844, p. 342. Captain Treloar, *Reports of the Saint John d'el Rey Company*, XX. 1849, p. 7; *Ibid*, XXIX. 1858, p. 29.

distinguish the formation in various parts * of its crooked course; viz.—

Name.	Direction.†	Dip.†
West Quebra Panella......	5°–8° S. of E. & N. of W.	S.‡
East Quebra Panella	10°–20° S. of E. & N. of W. ...	N. 79.°
Gut	10° N. of E. & S. of W.–E. & W.	S. 75°.
Bahù or *Bunch*	40°–50° S. of E. & N. of W.	N.E. 66°. S.W. 60°.
Bar	5°–15° E. of N. & W. of S. ...	E.*
West & Middle Cachoeira.	10°–20° S. of E. & N. of W. ...	N. 82°–89°.
East Cachoeira	10°–20° N. of E. & S. of W. ...	S. 62°.
Gambà W.	10°–20° S. of E. & N. of W.	S.
Gambà E.	10°–20° N. of E. & S. of W.	S.
North Branch	10°–25° N. of E. & S. of W. ...	S. 53°.§

The mean bearing is about 5° N. of E. and S. of W.‖

Owing as well to a difference of figure ¶ in the metalliferous mass, as to the jagged sides of certain newly opened parts remaining unstripped, ** the deeper works present fewer irregularities of outline and maintain a straighter course *(Pl. III.)* than those near the surface.††

(3.) Throughout its range the metalliferous mass—conforming as often to the jointed as to the schistose structure of the adjoining rock—exhibits changes alike

* "We have three mines—the Bahu, the Cachoeira, and the Gamba. The first "two are on the main lode, the last is on an off-shoot."—Captain Treloar, *Reports of the St. John d'el Rey Company*, xxviii. 1857, p. 27.

† Captain Treloar, MSS.

‡ Captain Treloar, *Reports of the St. John d'el Rey Company*, xxiii. 1852, p. 34.

§ *Ibid*, xxi. 1850, p. 21.

‖ In general direction the *lode* "where wrought approaches to east and west." *Ibid*, xxvii. 1856, p. 26.

¶ "The figure of the lode in the Bahù is altering * * * and its aspect is "improving"—*Ibid*, xix. 1848, p. 28.

** "In such a crooked and jagged lode a great deal of killas must necessarily "be broken."—Mr. Herring, *Ibid*, xvi. 1845, p. 37.

†† Henwood, *Cornwall Geol. Trans.* vi. *Pl. I.*

numerous, and sudden in underlie * and direction. The richer portions dip generally 65°—80°; but *(branches)* subordinate parts often incline at lower angles.

(4.) Bounded on opposite sides by unconformably shaped *(walls)* faces † of slate, the metalliferous deposit presents many differences in form and width *(Table VI. Pl. III.)*.

Name.	Depth. fms.	Width. Greatest. feet.	Smallest. feet.	Average. feet.
West and *East Quebra Panella* ...	39	—	2· ‡	11·5
	90	16·5§	—	
Gut	89	31·7	20·7	26·2 ‖
Bahú or *Bunch*	51	—	2·5¶	28.
	143	65· **	—	

* " Sometimes the lode inclines towards the north, at other times towards the " south."

Captain Treloar, *Reports of the Saint John d'el Rey Company*, xx. 1849, p. 5.

" At the *East Cachoeira* * * * owing to the hardness, contractedness, and " serpentine figure of the lode, we are under the necessity, in order to avoid " leaving behind us dangerous projecting masses of the containing rock, and for " advantage of quarrying, of keeping the excavation 18 feet wide in some places " where the lode is only 11 feet 8 inches."—*Ibid*, xxv. 1854, p. 30.

" In underlie the lode varies from south to north, but averages 83° towards the " south * * * seventy fathoms from the out-crop it widened generally, and the " lengths of the different sections remained the same. * * * In the next 50 " fathoms, vertically, the figures of the sections greatly changed; and the lode " inclined more south, widened at one locality contracted at another, and poor " white quartzose matter, invading it on the west, shortened the stoping ground."

Ibid, xxvii. 1856, p. 26.

" From the surface down, about 80 fathoms on the dip, the *Bahu* is north of " the *Cachoeira;* but in the next 70 fathoms, owing to enlargement of the lode " and local inflection, it becomes south."—*Ibid*, xxviii. 1857, p. 28.

† Henwood, *Cornwall Geol. Trans*, v. pp. 195-204. *Ante*, p. 131.

‡ Mr. Herring, *Reports of the Saint John d'el Rey Company*, xiii. 1842, p. 31.

§ Captain Treloar, *Ibid*, xxv. 1854, p. 26. ‖ Captain Treloar, MSS.

¶ Captain Treloar, *Reports of the Saint John d'el Rey Company*, xvi. 1845, p. 17.

** *Ibid*, xxxi. 1860, p. 40.

Bar	94	24·	15· *	18·5
West, Middle, and *East Cachoeira*	27 141	— 47· ‡	1·5 † —	18·2
Gambà	19 42	— 18· ‖	0·3 § —	8·1
North Branch	74 85	7· ¶ —	— 4· **	5·9

At different depths the average widths of various parts have been—

Depth.	The *Bahù* or *Bunch.* feet.	The *West, Middle, & East Cachoeira.* feet.
Surface to 50 fms. ...	.... 20·1	.... 11·7
50—100 „ ...	.... 21·1	.... 22·6
100—150 „ ...	.... 39·8 ††	.... 24·3

(5.) The formation, thus irregular in direction, dip, and dimension, is chiefly composed of quartz; ‡‡ in which, however, well defined angular masses of slate are often enclosed, The smaller ones are rather irregularly distributed; but the larger often correspond with the neighbouring *(country)* rock in lamination, and sometimes in jointed structure also.

Many such slices of slate are disposed lengthwise in the quartz.

* Captain Treloar, *Reports of the Saint John d'el Rey Company,* xxiii. 1852, p. 28.
† Mr. Herring, *Ibid,* xv. 1844, p. 11.
‡ Captain Treloar, *Ibid,* xxxi. 1860, p. 38. § Mr. Herring, *Ibid,* xv. 1844, p. 24.
‖ Captain Treloar, *Ibid,* xxviii. 1857, p. 41.
¶ *Ibid,* xx. 1849, p. 8. ** *Ibid,* xxii. 1851, p. 26.
†† At and below 74·8 fms. the works have included the *North Branch.* *Ibid,* xx. 1849, p. 10.
‡‡ " At the Bahu the lode is composed of quartz, killas, and pyrites in about " equal proportions."—*Ibid,* xxvii. 1856, p. 27.
" The matrix of the lode is quartz."—*Ibid,* xxix. 1858, p. 28; xxx. 1859, p. 26.

(5—1.) The *North branch (Fig.* 14, *b')*—part of the *Gamba lode**—is severed from the great metalliferous deposit (*b*) by *(the tongue of killas*†*)* a wedge-shaped mass of slate (*á*); the laminæ of which maintain the same position as those of the neighbouring rocks (*a*); but,—traversed by fewer, yet broader, joints,‡—are softer and more disintegrated than they. Dipping 53°§—66°|| towards the south, and broadest at the surface, its width,—for about one hundred and forty fathoms deep,—is nowhere more than fifteen or less

Fig. 14. MORRO VELHO. *Transverse Section.*

a Rock (*Country*) of clay-slate.

á Tongue (*horse*) between *North-branch* and great metalliferous deposit.

ä Laminæ, which—common to *Country* and *horse*—intersect both *North-branch* and principal metalliferous deposit.

b Metalliferous deposit. *b' North-branch.*

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* Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, & Dublin Phil. Mag.*, 3rd Series, XXV. p. 342. Captain Treloar, *Reports of the Saint John d'el Rey Company*, XXIII. 1852, p. 27.

† Captain Treloar, *Ibid*, XXII. 1851, p. 25.

‡ *Ibid*, XXI. 1850, p. 21; XXII. 1851, p. 26. § *Ibid*, XXI. 1850, p. 21.

|| *Ante*, p. 188.

than four feet.* At that depth, however, it widens; and some of its laminæ (*ä ä ä*) extending across, and entirely cutting through, the *North-branch* (*b′*) on one side and certain portions of the great metalliferous band (*b*) on the other, are prolonged into, and—retaining throughout their normal inclination 40°–70° south-east †—form integral parts‡ of, the *(wall)* rock-formation (*a a*) beyond.

It is both easier and cheaper to remove than to prop§ this thin, sloping slice of soft and jointed rock.

(5—2.) At different depths and unequal distances in the *Champion-ground*,‖ the *Quebra Panella*,¶ the

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* Captain Treloar, *Reports of the Saint John d'el Rey Company*, xx. 1849. p. 3; xxi. 1850, p. 21; xxii. 1851, pp. 25, 26; xxiii. 1852, p. 27; xxvii. 1856, p. 35.

† *Ante*, p. 188.

‡ "The tongue separating the North branch from the Main lode has thickened, "and portions of it shoot through the lode so as to form a junction with the "walls."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, xxviii. 1857, p. 39.

§ By embracing both the lode and the North branch in the same opening, we "not only add to our stoping-ground, and facilitate the quarrying in the Gut, "but * * * we are enabled to avoid a great deal of expensive timber-work, "which otherwise would be entailed on us, to support the tongue of killas rest-"ing on it."—*Ibid*, xxiii. 1852, p. 27.

‖ In the *Champion-ground* at the tram level the lode was "divided by a bar of "killas;" of which, at twenty fathoms deeper, there was "only a film."

§ *Ibid*, xxiv. 1853, p. 30.

¶ "At about 46 fathoms deep a shear of killas crosses the lode."

Captain Verran, *Ibid*, xv. 1844, p. 23.

In the *Quebra Panella* a bar of killas, which at about fifty-five fathoms deep is 45 feet wide, divides, but does not displace, the lode.

Captain Treloar, *Ibid*, xviii. 1847, p. 20; xix. 1848, p. 25.

"Some bars of quartzose killas which used to traverse the lode have dis-"appeared."—*Ibid*, xx. 1849, p. 15.

"At the eastern part of the *East Quebra Panella*, bars of killas shooting "nearly across the lode have presented themselves."—*Ibid*, xxi. 1850, p. 32.

"The lode is * * * divided by a bar of killas."—*Ibid*, xxii. 1851, p. 30.

"The ground * * * consists of alternate bars of lode and killas."

Ibid, xxv. 1854, p. 27.

*Bahù,** and the *Gamba,*† irregular bars of the thick lamellar clay-slate which forms both *(walls)* sides, extend in some places partly, but in others entirely, across the metalliferous vein-stone.

(5—3.) The chief metalliferous deposit and the *North-branch*—united at the *Quebra Panella*, a western part of the mine,—are, in like manner, severed ‡ by certain slightly-inclined laminæ of clay-slate; which,—at about one hundred and ten fathoms from the surface,—interlie and form portion of the adjoining *(Country)* rock on both sides *(walls)*; but—gradually diffused through the quartzose vein-stone—they occasion neither vertical nor horizontal displacement.

Thus, the laminæ which form, and the joints which bound, the included *(tongue of killas)* slice of slate, not only maintain an exact coincidence with those of the neighbouring *(Country)* rock; but, in one place at least, the same *foliæ*—severing both the intervening masses of auriferous vein-stone—interlie, and form

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* "A bed of quartzose slate slightly charged with iron pyrites separates the "*Bahù* from the *Western Cachoeira*."—Henwood, *Cornwall Geol. Trans.* vi. p. 144.; *London, Edinburgh & Dublin Phil. Mag.*, 3rd series, xxv. 1844, p. 342.

"Between the *Bahù* and the *Cachoeira* a bar of ground intervenes, composed "chiefly of lody matter and killas. Its thickness varies from 15 feet in some "places to 24 feet in others."—Captain Treloar, *Reports of the St. John d'el Rey Company*, xxiii. 1852, p. 28; xxx. 1859, p. 27.

† The *Gambâ lode* at 24·5 fathoms deep "was at one place actually divided by "killas," but at a depth of 29 fathoms it "presented only a *splice* with no killas "intervening."—*Ibid*, xvii. 1846, p. 20.

‡ At about 110 fathoms deep in the East Quebra Panella a portion of the lode which, from the surface downward, had been especially quartzose, was unseated by killas; but,—after exciting some apprehension—this was ultimately found to be merely a thin layer, underneath which appeared hard quartzose matter resembling the Cornish miner's "Capel."

Ibid, xxiv. 1853, p. 32; xxv. 1854, p. 26; xxvi. 1855, p. 33.

constituent portions, as well of the enclosed slice, as of the slate formation on either side. In many cases, also, the identical laminæ which sever the quartzose matrix in some places, are severed by it in others; phenomena nowhere common, yet not unexampled* in the tin-*lodes* of Cornwall.

(*b.*) Transitions so abrupt and immediate as these, are, however, neither of constant nor even common occurrence at the contact of either containing rocks *(walls)*, included slices *(horses)*, or smaller embedded masses of slate, with quartzose vein-stones; but, contrariwise, the two are often so intimately mixed,† that the prevalence of one or other ingredient is indicated by a mere difference of hue. Sometimes, however, both sudden and gradual transitions occur within very narrow limits.

Quartz, quartzose slate, and slate in smaller quantities, are mixed with pyrites; which,—assuming in different places most of the modes already described,‡—forms, in some cases, great part of the deposit. To about one hundred and twenty fathoms from the surface, common, magnetic, and white iron pyrites prevail; § but at greater depths arsenical pyrites also

* Henwood, *Cornwall Geol. Trans.*, v. p. 326; *Tables XIV., XLIII., LII.*

† "The connexion between the metalliferous mass and the contiguous rock is "by a gradual transition; the pyritous matter, which prevails in its central por-"tions, being progressively replaced by quartzose and slaty substances towards "the sides."—Henwood, *Cornwall Geol. Trans.*, vi. p. 144; *London, Edinburgh, and Dublin Phil. Mag.*, xxv. 1844, p. 342.

‡ *Ante*, pp. 6, 76.

§ von Spix und von Martius, *Reise in Brasilien*, ii. p. 417. Caldcleugh, *Travels in South America*, ii. p. 271. Henwood, *Cornwall Geol. Trans.*, vi. p. 144; *London, Edinburgh, and Dublin Phil. Mag.*, xxv. 1844, p. 342. Captain Treloar, *Reports of the St. John d'el Rey Company. Passim.*

abounds.* Isolated masses of yellow copper-ore † occur at intervals, but they are neither large nor numerous. In different parts of the mine open joints whence inflammable gas ‡ has sometimes issued, and drusy

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* Caldcleugh, *Travels in South America*, II. p. 271. Henwood, *Cornwall Geol. Trans.*, VI. p. 144.

" The quartzose matter is frequently interspersed with small bunches of arseni-" cal and copper pyrites."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, XXVI. 1855, p. 32.

" The arsenical pyrites has increased in quantity, especially in the quartzose " portions."—*Ibid*, XXVII. 1856, p. 57.

" The gold is chiefly associated with arsenical pyrites."—*Ibid*, p. 35.

" At the Bahu, arsenical pyrites not only maintains its hold, but the quartzose " portions in particular are becoming more highly charged with it; and the aurif-" erous property of such localities is very satisfactory. * * * We have entered " a zone where the predominating elements of the lode are quartz and arsenical " pyrites instead of quartz and iron pyrites."—*Ibid*, XXVIII. 1857, p. 31.

" When common iron pyrites was in the ascendant the lode had somewhat the " appearance of plumbago: but when the requisite leaven of quartz presented " itself, it brightened, and arsenical pyrites became more plentiful."

Ibid, XXXI. 1860, p. 28.

† von Spix und von Martius, *Reise in Brasilien* II. p. 417. Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, & Dublin Phil. Mag.*, XXV. 1844, p. 342. Captain Treloar, *Reports of the Saint John d'el Rey Company*, XXVI. 1855, p. 32.

‡ " While a hole was being bored at the south or hanging-wall side, close " to the junction of the *lode* and the enclosing rock, at 104 fathoms from the " surface," in the Cachoeira mine, " a pale blue flame issued from it. On re-" moving the borer the flame rose to a height of ten or twelve inches, and con-" tinued—as it were—to ebb and flow for about a minute, and was then gradually " extinguished. On applying a light to the hole, after the lapse of a few minutes, " the flame re-appeared, but more feebly than at first."

" The light being put out, the hole was blasted with gunpowder and disclosed " a *bunch* of quartz of about a fathom in length by six inches in width, full of " *vughs*, and running transversely to the planes of the containing rock."

" The apertures were carefully plugged with clay, and a second hole was bored " deeper than the first had reached * * * and the hole itself was in like manner " closed. On making an opening of about one-eighth of an inch in diameter in " the clay which filled the mouth of the hole and applying a light to the aperture " on the following morning, a flame almost like a jet of coal-gas rose some four " inches high. Near the orifice its colour was pale blue, but at the top it was " yellow. Once only—when the flow of gas was not plentiful—a slight explosion " took place."

cavities,* most frequent near the surface, are often lined with crystals of quartz, arragonite, and spathose iron.

Quartz is the general,—quartzose-slate a less frequent,—and slate † an uncommon and a mere casual matrix of pyrites.

The quartz, however, is seldom or never more than slightly auriferous; ‡ nor, indeed, is the pyrites itself often rich; § yet a mixture of quartz with pyrites forms,—in the deeper parts of *Morro Velho* at least,—

"No odour of garlic was perceptible during the combustion, nor was any de-"posit left on porcelain held over it."

Captain Treloar, *Cornwall Geol. Trans.* vii. p. 345; *Reports of the Saint John d'el Rey Company*, xxix. 1858, p. 34.

"A little gas, similar in kind to that noticed at the Cachoeira, issued from a "fissure" in a less cellular part of the lode, about 150 fathoms deep in the Bahu mine.—*Ibid*, xxx. 1859, p. 37.

* Henwood, *Cornwall Geol. Trans.*, vi. p. 144; *London, Edinburgh, & Dublin Phil. Mag.* xxv. 3rd series, 1844, p. 342. Captain Treloar, *Reports of the Saint John d'el Rey Company*, xvii. 1846, p. 18; xx. 1849, p. 3; xxi. 1850, p. 20; xxii. 1851, p. 25; xxiii. 1852, pp. 26, 31; xxvii. 1856, p. 27.

† "Resting on the North branch in the Bahu * * * there are about 13,000 "tons of killas, worth perhaps only about one oitava" (55·33 grains or 0·00000353 its weight) "of gold per ton."—*Ibid*, xx. 1849, p. 13.

"We have commenced systematically separating and rejecting, for the present, "that portion of the ore which we call 'Black, or dead Killas,' and which we "find will yield only 0·6 of an oitava per ton" (33·198 grains or 0·00000212 its weight) "of gold."—Messrs. Walker & Reay, *Ibid*, xxiv. 1853, p. 43.

‡ "One sample from the quartz yielded by assay at the rate of 0·56 oitava of "gold per ton" (31·08 grains or 0·00000198 its weight).

Captain Treloar, *Ibid*, xxiv. 1853, p. 26.

§ "At the Cachoeira mine the lode has * * * greatly improved in its pyrit-"iferous character, but hitherto no corresponding amendment has occurred in its "auriferous property."—*Ibid*, xxvi. 1855, p. 25.

"Neither the pyritic contents, nor the average size," of the lode "has ever "been equalled; yet its auriferous character was never at so low an ebb."

Ibid, xxvii. 1856, p. 26.

"The pyritic aspect of the lode continues too good."

Ibid, xxviii. 1857, p. 36.

the most congenial matrix * of gold ; but, even within compass of a few fathoms, the proportions of these ingredients are rarely constant.

The different qualities, prevalent in the adjoining parts of the mass, are shown by *(Table VI.a*)* monthly assays of average samples. From these we learn that the produce—

of consecutive months has differed		(from 0·0000250 to 0·0000349)	0·0000099 ;—
,, months in the same year	,,	(,, 0·0000229 ,, 0·0000367)	0·0000138 ;—
from June, 1855, to Dec., 1860......	,,	(,, 0·0000145 ,, 0·0000367)	0·0000222 ; &
during the same period has averaged....		(358 grains to the ton)	0·0000229 ;
whilst the mean of every assay from 1837 to 1860 has been		(367 ,,)	0·0000234

the weight of ore.†

Whilst some parts of the formation afford mere traces, others contain as much as (52 oitavas or 2877·16 grains per ton) 0·0001835 their weight of gold.‡ The pyrites, however—less equably distributed at great depths, than near the surface §—is often more richly impregnated when aggregated in isolated masses than when thoroughly diffused through the vein-stone.

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* " Experience has * * * demonstrated that a superabundance throughout of " pyrites is as antagonistic to gold as a preponderance of quartz. The latter " may be described as the soil, the former as the manure; so both are essential " to the developement of gold; but when either is too much in excess, the " auriferous property of the lode is impoverished."—*Ibid,* xxx. 1859, p. 25.

" A superabundance of pyrites is obstructive to the developement of gold as " profusion of quartz."—*Ibid,* xxxi. 1860, p. 28.

† *Table VII.*, column 11.

‡ " A sample, taken from the bunches of pyrites in the quartzose portion of " lode yielded at the rate of 52 oitavas of gold per ton."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, xxiv. 1853, p. 26.

§ " The lode, taken as a whole is maintaining its size, and its auriferous quality " is equal to what it was in our former prosperous days; but the precious metal " is not, I believe, so generally disseminated in it."—*Ibid,* xxxi. 1860, p. 27.

The quantities of gold extracted have also differed,—
in consecutive months ...... (from 0·0000208 to 0·0000232) 0·0000024;—
within the same year .... („ 0·0000112 „ 0·0000169) 0·0000057;—
from June, 1855, to Dec., 1860, („ 0·0000093 „ 0·0000232) 0·0000139; but
the average, meanwhile, has been .... (209·65 grains per ton) 0·0000134
the weight of ore crushed, washed *(dressed)*, and amalgamated *(Table VI.[a])*,
besides .... (8·322 grains per ton) 0·00000053
afterwards obtained by again treating the same ore (on the *Praia* *).

From 1838 to 1860 the mean yield was 219·75 grains per ton, or 0·0000140 the weight of ore.

By ordinary *(dressing)* treatment, however, different quantities of gold are, at times, extracted from ores which give the same assay. The following, with many other, examples occur in *Table VI.[a]*

Date.	GOLD.			
	Assay.		Actual yield.	
	Grains of gold per ton (*Avoir.*) of ore.	Proportion of gold in ore.	Grains of gold per ton (*Avoir.*) of ore.	Proportion of gold in ore.
1858, December..	314·108	0·0000200	173·514	0·0000111 }
1859, April	314·440	0·0000200	169·641	0·0000108 }
1856, July	315·768	0·0000201	190·113	0·0000121 }
1857, March	315·564	0·0000201	172·740	0·0000110 }
1856, April......	318·645	0·0000203	193·821	0·0000124 }
1857, February ..	318·756	0·0000203	182·754	0·0000117 }
1858, August....	318·700	0 0000203	168·922	0·0000108 }
1860, February ..	405·458	0·0000259	272·555	0·0000174 }
„ March	405·956	0·0000259	300·995	0·0000192 }
1860, January ..	424·381	0·0000270	261·323	0·0000167 }
„ August....	424·159	0·0000270	290·925	0·0000185 }
1855, 7 months ..	431·020	0·0000274	217·321	0·0000139 }
1860, whole year .	433·565	0·0000276	292·976	0·0000187 }

* *Reports of the Saint John d'el Rey Company*, XXVII. 1856, p. 40; XXVIII. 1857, p. 47; XXIX. 1858, p. 43; XXX. 1859, p. 43; XXXI. 1860, p. 48. *Table VI.a*
† *Table VII.*, column 25.

Although some of these discrepant results may have been affected by occasional modifications in the process of reduction, they chiefly depend on the greater or less ease with which gold is freed from the various ingredients of its matrix, in different parts of the mine.

(*b* 1.) The hardness of metalliferous deposits, has such a relation to the ores they contain,* that—irrespective of any obstacles or facilities it may present—it is an object of paramount interest to the miner. Annual accounts of—the ore extracted,†—the depths whence it was obtained,†—the holes bored,†—and the workmen employed in blasting,† supply means for comparing the hardness of the metalliferous mass at *Morro Velho.*

Depths. Extremes. fms.	Depths. Means. fms.	Holes bored; per man, per day.	Tons of crude ore broken; per man, per day.	Tons of crude ore broken; per hole.
50· to 100·	86·3	0·864	1·027	1·182
100· „ 123·8	123·8	0·920	1·139	1·237
Mean of eleven years	113·5‡	0·906‡	10·08‡	1·222‡

* Borlase, *Natural History of Cornwall*, p. 152. Jars, *Voyages Métallurgiques* III. pp. 86, 190, 195. Pryce, *Mineralogia Cornubiensis*, pp. 89, 91–94. Werner, *New Theory of the Formation of Veins*, p. 122. Daubuisson, *Des Mines de Freiberg*, I. p. 53; III. pp. 56, 153, 243. Phillips, *Geol. Transactions*, II. p. 132. Carne, *Cornwall Geol. Trans.*, III. p. 80. Fox, *Report of the Royal Cornwall Polytechnic Society*, 1836, p. 86. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 336. Henwood, *Cornwall Geol. Trans.*, V. pp. 183, 212, 221, 224, 226, 228, 230; VI. p. 145; *Ante*, pp. 84, 125.

"An experiment of single-handed boring was tried, but failed from the ex-"cessive hardness of the lode."—Mr. Herring, *Reports of the Saint John d'el Rey Company*, VIII. 1837, p. 23.

"The system of boring with 'jumpers' has been tried, by a man who pro-"fesses to be an experienced hand, and he signally failed."

Captain Treloar, *Ibid*, XXIV. 1853, p. 27.

† *Reports of the Saint John d'el Rey Company*, 1850—1860. *Table VII.*, columns 2, 5, 6, 7, 8.

‡ *Table VII.*, columns 2, 5, 6, 7, 8, lines 29, 30, 31.

The progressively larger quantities of ore pulverized

A comparison of the means employed with the work accomplished in the broader parts of different mines may not be out of place here.

Mine.	Rock.	Vein-stone and ore.	Diameter of hole. Inches.	Depth of hole bored per man per day. Inches.	Gunpowder used per man per day. lb. (*Avoir.*)	Vein-stone blasted; per man, per day. Tons.	Vein-stone blasted; per lb. (*Avoir*) of gunpowder. Tons.	Authority.
Morro Velho	Clay-slate.	Quartz, slate, & pyrites.	2·	28·5	0·788	1·108	0·873	John Hockin, Esq. MSS. *Reports of the St. John d'el Rey Co.* XXI. XXXI.
Cronebane, Wicklow .	Clay-slate.	Quartz, slate, & pyrites.	1·5	48·	0·625	1·	1·600	John Reed, Esq. MSS.
Polberro, Cornwall ..	Clay-slate.	Quartz, slate, chlorite, & tin-ore (soft).	1·25	20·	0·344	2·	5·814	Michael Morcom, Esq. MSS.
Drake Walls, ,, ..	Clay-slate.	Quartz, slate, & tin-ore.	1·75	35·	0·970	1·287	1·327	Capt. Gregory, MSS.
Dolcoath, ,, ..	Granite ..	Quartz, felspar, chlorite, & tin-ore.	1·5	40·5	0·562	0·750	1·333	Captains Thomas and Tonkin. MSS.
Balleswidden, ,, ..	Granite ..	Felspar, quartz, schorl, and tin-ore.	1·5	60·	1·125	0·750	0·666	Captain Trahair. MSS.

by the same *stamping-power** whilst the mine has been sunk, confirms the conclusion, that the deeper are the softer parts of this formation.

(*b* 2.) Crude ore from different depths has yielded, under ordinary treatment, the undermentioned proportions of gold;†—

Depths. Extremes. fms.	Means. fms.	Gold extracted. Grains ℔ ton (*Av.*) of ore.	Proportion of mass.
Surface to 50· ..	33·8	225·35	0·0000144
50· „ 100· ..	71·8	215·57	0·0000137
100· „ 142·8..	123·8	205·84	0·0000131
Mean	78.3	210·79	0·0000135

" C'est relativement à la quantité de poudre nécessaire pour charger les trous " de mines, que l'expérience pratique des mineurs est le plus ordinairement en " défaut: la plupart proportionent tout simplement la dose de poudre à la pro- " fondeur du trou, de telle sorte que la poudre remplisse une fraction déterminée, " un tiers, par exemple, ou un quart de cette profondeur: une pareille règle " appliquée sans avoir égard à la nature de la roche, et même à la position du " trou par rapport aux parois dégagées, et à son diamètre n'a évidemment rien de " rationnel. Le major général Sir J. F. Burgoyne, dans un mémoire récent sur " le tirage des rochers à la poudre, conseille de suivre la règle suivante: en " supposant qu' une roche ait une égale ténacité dans tous les sens, les charges " de poudre à employer devront être proportionnelles aux cubes des lignes de " moindre résistance, qui, dans ce cas, ne sont autre chose que les plus courtes " distances de la charge aux faces dégagées de la roche.

" Ainsi, dans les carrières de granite de Kingstown près Dublin, les charges " de poudre exprimées en onces avoir-du-pois, étaient prises égales à la moieté " des cubes des lignes de moindre résistance exprimées en pieds anglais, sans " avoir égard à la profondeur des trous."

* * * * * * * * *

" La charge de poudre exprimée en grammes est égale à 529 fois le cube de la " ligne de moindre résistance exprimée en mètres. Cette règle revient à peu " près à la suivante, qui est exprimée par des rapports en nombres plus simples: " *La charge de poudre en grammes est égale à la moieté du cube de la ligne de* " *moindre résistance exprimée en décimetrès.*"

Combes, *Traité de l'Exploitation des Mines*, I. pp. 241–3.

* *Table VII.*, columns 13, 14.

† *Table VII.*, columns 2, 8, 25.

Much rubbish is carefully separated * before the ore is stamped.

Depth.		Crude ore.	Rubbish rejected.	
fms.		Tons.	Tons.	Proportion of mass.
Surface to	50·	85·844	11·213	0·131
50· ,,	100·	475·125	16·577	0·035
100· ,,	142·8	712·251	32·056	0·045
Mean..	78·3	—	—	0·047

Ore from different depths, when selected and pre-

A comparison with results obtained at one of the most carefully managed tin-mines in Cornwall may not be uninstructive.

During the year 1861 *Polberro* afforded—

43,638 tons (*Avoirdupois*) of crude tin-ore; which contained

	tons.			tons.	tons.
(*a.*) Tin-(*stuff*) ore fit for the *stamps*,	28,937·		(*b.*) Refuse		14,701·
of which there were obtained by					
(1.) *Tributers* (paid a proportion of the value)	27,187·6	which yielded when *stamped* and washed (*dressed*)	(*a.*) Tin-ore (black tin fit for the furnace	185·167	
			(*b.*) Refuse		27,002·433
(2.) *Tut-work* men (paid a fixed price per fathom)	1,749·4	,,	(*a.*) Tin-ore	6·489	
			(*b.*) Refuse		1,742·911
	28,937·			191·656	43,446·344
In addition to this there were also culled from amongst the (*burrows*) refuse	3,567·9	,,	(*a.*) Tin-ore	12·200	
			(*b.*) Refuse		35,55·700

When brought to the surface crude ore contains on an average 9·843 lbs. per ton, or 0·004392 its weight of (*black*-tin) ore fit for the furnace.

When prepared for the *stamps*, however, (tin-*stuff*) ore obtained by workmen of different classes contains the undermentioned proportions (of *black*-tin) ready for the smelter;—

	lbs. of (*black tin*) in each ton *Avoir.* of *tin-stuff*.	Proportions.
Obtained by *Tributers*	15·264	0·006818
,, *Tut-work* men	8·300	0·003709
Culled from amongst the refuse	7·659	0·003419.

Compiled from MSS. of Michael Morcom, Esq., Purser of the *Polberro* Mines.

* *Table VII.*, columns 2, 8, 9.

pared for the *stamps*, has yielded gold in the following proportions: *—

Depths.			Gold extracted.	
Extremes. fms.		Means. fms.	Grains ℔ ton *(Avoir.)* of ore.	Proportion of mass.
Surface to 50·	..	33·8 ..	249·87 ..	0·0000159
50· „ 100·	..	71·8 ..	221·93 ..	0·0000142
100· „ 142·8	..	123·8 ..	216·05 ..	0·0000138
Mean		78·3 ..	219·75 ..	0·0000140

The surface of cured-hides and baize, over which the stamped-ore is passed, has been of late much enlarged;† but the additional quantity of amalgamable ore thus collected is much poorer than that obtained by the means previously in use.‡

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* *Table VII.*, columns 10, 25.

† As the sand (pulverized ore) escapes from beneath the *stamp-heads* (through the *grates*), it is passed over............ 4,415 square feet of *cured hides*, and
2,472 „ coarse baize,
on which the richest portions subside.

From these, however, the remainder is now conducted to a second similar series consisting of.................... 2,415 square feet of *cured-hides*, and
1,039 „ baize;
and on these a further accumulation of ore takes place.

Mr. Reay, *Reports of the Saint John d'el Rey Company*, xxv. 1854, p. 35.
Table VII., column 15; Note *k*.

‡ The quantities of gold obtained by different appliances from each ton of ore stamped, has averaged

Years.	From ore collected on second series of cured-hides and baize. grains.	From ore ground in *arrastres.* grains.	Total yield by every method. grains.
1854	...... 1·99	..... 11·77	..... 230·72
5	...... 2·65	..... 11·12	..... 220·21
6	...... —	..... 9·85	..... 194·76
7	...... —	..... 8·57	..... 164·33
8	...... —	..... 9·79	..... 172·40
9	...... —	..... 11·51	..... 215·84
1860	...... —	..... 13·11	..... 293·08

Reports of the Saint John d'el Rey Company, xxv. 1854, p. 34; xxvi. p. 41; xxvii. p. 40; xxviii. p. 47; xxix. p. 43; xxx. p. 43; xxxi. p. 48.

The following columns contrast assays of ore prepared for the *stamps* with the proceeds of its reduction.

Years.	Gold. Assay.* Grains of Gold per ton (*Av.*) of ore.	Assay.* Proportion.	Proceeds.* Grains of Gold per ton (*Av.*) of ore.	Proceeds.* Proportion.	Loss. Grains of Gold per ton (*Av.*) of ore.	Loss. Proportion.	Loss. Per centage of assay.
1855....	.... 431·02	0·0000275	.... 220·21	0·0000140	.... 210·81	0·0000135	.. 48·92
6....	.... 326·50	0·0000208	.... 194·76	0·0000124	.... 131·74	0·0000084	.. 40·35
7....	.... 288·00	0·0000184	.... 164·33	0·0000105	.... 123·67	0·0000079	.. 42·94
8....	.... 210·78	0·0000198	.... 172·40	0·0000110	.... 138·38	0·0000088	.. 44·53
9....	.... 359·64	0·0000229	.... 215·84	0·0000138	.... 143·80	0·0000091	.. 32·98
1860....	.... 433·56	0·0000277	.... 293·08	0·0000187	.... 140·48	0·0000090	.. 32·41

* *Reports of the Saint John d'el Rey Company*, XXVI. 1835, p. 45; XXVII. p. 44; XXVIII. p. 51; XXIX. p. 46; XXX. p. 44; XXXI. 1860, p. 49. *Tables VI.a, VII.*, columns 11, 25.

Since monthly assays of ore prepared for the *stamps* were established * in 1855, the loss of gold during reduction has been diminished (from 48·92 to 32·41) 16·51 per cent.; a difference which now affords profit from ore which could formerly have been wrought only at a loss. Meanwhile the mine was deepened (from 116·6 to 142·8†) 26·2 fathoms.

The assay of ores obtained from so small a vertical range affords but little aid in ascertaining any differences of quality prevalent at various depths in the metalliferous deposit.

The proportionate *yield* of gold, from ores extracted at different depths, has been,

Depth. fms.	Gold. Proportion yielded by Crude ore.	Ore made ready for the *stamps*.
Surface to 50· ..	1·	1·
50· ,, 100· ..	0·956	0·888
100· ,, 142·8 ..	0·912	0·865

Thus, as the mine was deepened, its ores yielded a gradually smaller proportion of gold.

(*b* 3.) Meanwhile, more efficaceous appliances collected larger quantities of amalgamable ore, which afforded, progressively, gold of greater fineness.‡

Depths. fms.	Quality *(toca)* of Gold. Actual. Carats.	grains.	Comparative.
Surface to 50	18	3·687	1·
50 ,, 100	19	0·183	1·006
100 ,, 142·8	19	0·288	1·008

(*b* 4.) The quantity of silver obtained was greater

* By John Hockin, Esq., Managing Director of the Saint John d'el Rey Company.

† *Table VII.*, column 2. ‡ *Table VII.*, columns, 2, 28, 29, 30.

also, as the gold it had been associated with was extracted from more deeply-seated ores.*

Depths. fms.	Silver in unrefined gold, Grains of, ℔ lb. *(Troy)*.	Proportion of mass.	Comparative.
50 to 100	1,108·1	0·1924	1·
100 „ 142·8	1,131·2	0·1998	1·02
Mean........	1,118·4	0·1942	—

The results obtained in several foregoing pages, are compared in the following columns.

Depth. fms.	Width of formation.		Hardness of vein-stone.	Richness of		Quality of gold.	Silver.
	Bahù.	*Cachoeira.*		Crude ore.	Ore prepared for *stamps*.		
Surface to 50·	1·	1·	——†	1·	1·	1·	——†
50· „ 100·	1·050	1·932	1·	0·956	0·888	1·006	1·
100· „ 142·8	1·482	2:077	0·902	0·912	0·865	1·008	1·020

Thus, to a depth of 142·8 fathoms the vein-stones are softer, and the silver is more plentiful; yet—owing to the still smaller proportions of other foreign substances,—the gold is of better quality, in deeper, than in shallower, parts of the mine.

(5–5.) Whether parallel, oblique, or transverse, in direction, to the schistose structure of the adjoining slates, the formation and its branches have—with trifling exceptions—a prevailing inclination to the south.‡ Meanwhile the several rich masses or *bunches* of auriferous pyrites in the *Bahù*, the *Cachoeira*, and the *Gambà* as well as the bodies of unproductive vein-stone between them, have an end-long dip or *shoot*

* John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS. *Table VII.,* columns 2, 31.

† Unrecorded. ‡ *Ante*, p. 188.

of seldom less than 43°, but never more than 47°—towards the east,* obedient to both these inclinations, and dipping with the neighbouring slates;—the *Bahú, Cachoeira, Catta Branca stopes,*† and other portions of the formation, are, at the bottom of the mine, one hundred and forty fathoms south-east of their counterparts at the surface *(Pl. III.)*.

Whether the metalliferous deposit—partaking, as usual, the nature of the neighbouring rocks—be faced by the edges of their laminæ and bounded by joints; or—interlying them—conform to their flexures; its sides, and the faces *(walls)* of slate adjoining them, produce undulations, flutings, grooves, and *striæ* which coincide as well with the schistose structure, as with the *shoots* or *bunches* of ore and masses of vein-stone in general dip‡ towards the south-east.

* "The whole mass of lode and its branches, move bodily forward and down-"ward in a nearly true east direction."

Mr. Herring, *Reports of the Saint John d'el Rey Company,* ix. (1838) p. 29.

"The dip of the lode itself carries the whole mineral deposit 5 feet 10 inches "to the east, for every 6 feet that is sunk.—*Ibid,* xi. (1840), p. 34.

"Four well-marked enlargements of the metalliferous deposit at *Morro Velho,* "respectively preserve the same relative positions, the same configuration, and "indeed almost exactly the same dimensions to the depth of 42 fathoms, as they "expose in their outcrop at the surface. They have a regular inclination of "about 45° towards the east, on a line which bears 2° S. of E. & N. of W; and "this regularity equally prevails whether the dip of the formation may be paral-"lel or oblique to the cleavage of the containing rock."

Henwood, *Cornwall Geol. Trans.* vi. p. 146, *Pl. I.; London, Edinburgh, and Dublin Phil. Mag.,* 3rd series, xxv. (1844) p. 343.

"Its general direction approaches to east and west; its underlie varies from "south to north, but averages 83° towards the south. The direction of its dip "varies from south 58° east to south 82° east, and the inclination from 42 to 47°."

Captain Treloar, *Reports of the Saint John d'el Rey Company,* xxvii. (1858) p. 26.

† *Ibid,* xxiv. (1853) p. 32.

‡ "Certain 'slides' of ground * * * which accompany the * * * dip of the

Between 30th November, 1834, and 21st March, 1862,*

		lbs. (*Troy*)		
Morro Velho yielded		59,098·654*	of gold, worth	£2,229,487;*
of which there was paid to the Government of Brazil as				
	lbs. (*Troy*)			
Provincial duties,	2,211·820, worth £86,391			
Export duties, ..	54·868, ,, 2,143	2,266·688	,, ,,	88,534.
The remaining		lbs. 56,831·966	,, realized	£2,140,953

The expenditure, from 1st Jan., 1838, to 31st May, 1862, amounted to	£1,472,327*	
,, loss in 1854—7 .... ,,	6,889	1,479,216
,, net profit therefore was		£ 661,737.*

Of this magnificent sum, a portion (augmented by accumulated interest to thirty-five thousand three

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"shoots of ore * * * have been exceedingly regular."—Mr. Herring, *Ibid*, xiii. (1842) p. 36.

"A circumstance of value to the miner, as well as of interest to the geologist, "—common to most, if not all, the Brazilian mines worked in schistose rocks,— "is that, whether the veins may be parallel, oblique, or transverse to the laminæ, "their sides *(walls)* are grooved or fluted with large *striæ*, which coincide with "the dips of the *shoots* of gold, both in the amount and in the direction of their "inclination."—Henwood, *Cornwall Geol. Trans.* vi. p. 146; *London, Edinburgh, and Dublin Phil. Mag*, 3rd series, xxv. (1844) p. 343.

The dip "is every where parallel to the striæ."—Captain Treloar, *Reports of the Saint John d'el Rey Company*, xxvii. (1857) p. 27; xxviii. (1358) p. 44.

* The results of operations at *Morro Velho* during the year 1861 were,—

Crude ore broken in the Mine. Tons.	Rubbish rejected. Tons.	Ore stamped. Tons.	Gold. Grains in each ton (*Avoir.*) of ore.	Gold. Quantity extracted. lbs. (*Troy.*)
96,612·2 *a*	24,033·6	71,902·4	383·99	5,050·907

From 19th March, 1861, to 21st March, 1862,—

5,200·689 lbs. (*Troy*) of gold were obtained; which realized	£212,813
The expenditure for the year ending 31st May, 1862, was	116,044
The profit therefore amounted to	£ 96,769

a Crude ore unstamped, 686·2 *tons.*

Reports of the Saint John d'el Rey Company, xxxii. (1861) pp. 5, 22, 24, 25, 57, 59, 60.

hundred and seventy-three pounds) forms a *Reserved Fund;* *—nineteen thousand five hundred and seven pounds have been transferred to the *Capital Account;* —and five hundred and fifty-eight thousand two hundred and fifty pounds have been divided amongst the fortunate shareholders.

From every part of this district—formerly a rich one,† gold is still obtained; but the other mines ‡ now wrought are small and poor.

(IV.) (*a.*) At Ouro Preto § buff-coloured, granular,

* *Reports of the Saint John d'el Rey Company,* XXXII. (1861) p. 19.

† Southey, *History of Brazil,* III. pp. 56, 283. Mawe, *Travels in the interior of Brazil,* p. 386. Caldcleugh, *Travels in South America,* II. pp. 273-7. von Spix und von Martius, *Reise in Brasilien,* II. p. 417. von Eschwege, *Pluto Brasiliensis,* pp. 16, 441; *Tabellarische Uebersicht aller Gold lavaras jeden Districts in der Provinz Minas Geraes,* pp. XIII.-XVII. Saint Hilaire, *Voyage dans le district des Diamans, et sur le littoral du Brésil,* II. p. 168. Claussen, *Bulletins de l'Académie Royale de Bruxelles,* VIII. 1re partie, p. 323. Gardner, *Travels in Brazil,* p. 495. Henwood, *Cornwall Geol, Trans.* VI. p. 143; *London, Edinburgh, and Dublin Phil. Mag.,* 3rd series, XXV. (1844) p. 341.

‡ Attempts to work ill-ventilated parts of *Bella Fama* by the light of fire-flies were made by Colonel Trollé; but without success.

MSS. of the late JOHN HENRY BELDEN, ESQ., M.D., of Sabará.

§ "Villa Rica (Ouro Preto) a si peu de régularité, qu'il est extrêmement difficile d'en donner une idée très-exacte. Elle est bâtie sur une longue suite de "mornes qui bordent le Rio d'Ouro Preto et qui en dessinent les sinuosités. Les "uns sont plus avancés; d'autres reculés davantage forment des gorges assez "profondes; quelques-uns, trop à pic pour recevoir des habitations, ne présentent, "au milieu de ceux qui les environnent, qu'une végétation assez maigre et de "grandes excavations. Les maisons se trouvent ainsi disposées par groupes "inegaux, et chacune est, pour ainsi dire, construite sur un plan différent. La "plupart ont un petit jardin long et étroit, assez mal soigne. Ces jardins sont "soutenus par une muraille peu élevée, presque toujours couverte d'une immense "quantité de fougères, de graminées, de mousses, et le plus souvent ils forment "les uns audessus des autres une suite de terrasses dont l'ensemble présente "quelquefois une masse de verdure, telle qu'on n'en vit jamais dans nos climats "tempérés. De ces maisons ainsi entremêlées de sommets arides et de touffes "serrées de végétaux, il résulte des points de vue aussi variés que pittoresques; "mais la couleur noirâtre du sol, celle des toits qui n'est guère moins obscure,

flags (" the elastic sandstone of Villa Rica " *), composed of quartz and mica, are overlaid by thick lamellar, homogeneous, soft, blue clay-slate, of silky lustre; of which, the upper members,—often darker in colour,—are, at intervals, shaded with either pink, red, or brown.

Although the clay-slate is seldom destitute of gold, the more deeply tinted portions only contain enough to pay the workman: from these, however, some few poor people still obtain a scanty livelihood.

" le vert foncé des orangers et des cafiers tres-multipliés dans les jardins, un ciel " presque toujours nuageux, la stérilité des mornes où l'on n'a point bâti, com- " muniquent au paysage un aspect sombre et mélancolique.

* * * * * * *

" Les petits jardins * * * sont généralement assez mal soignés. Des orangers, " des caféyers, des bananiers, y sont plantés presque toujours sans ordre. Les " choux sont le principal légume qu'on y cultive; et, parmi les fleurs, celles qui " ont le plus de vogue sont les œillets et la rose de Bengale, qui a conservé sa " couleur primitive."

* * * * * *

" Dans la vallée où nous étions descendus, coule le Rio d'Ouro Preto, petite " rivière dont les eaux, peu abondantes, sont sans cesse divisée et subdivisées par " les chercheurs d'or, et dont le lit d'un rouge noir ne présente plus que des filets " d'eau qui coulent entre des amas de cailloux noirâtres, résidu des lavages."

Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro, et de Minas Geraes*, I. pp. 137, 139, 149.

Mawe, *Travels in the interior of Brazil*, pp. 238-9. von Spix und von Martius, *Reise in Brasilien*, I. pp. 368-9. Southey, *History of Brazil*, III. p. 56. Walsh, *Notices of Brazil*, II. pp. 191-195. Gardner, *Travels in Brazil*, pp. 509-512.

* Caldcleugh, *Travels in South America*, II. p. 259. von Eschwege, *Annales des Mines*, VIII. (1823) p. 411; *Pluto Brasiliensis*, p. 218.

" Der quartzreiche, körnige Glimmerschiefer, Gelenquartz, elastische Sand- " stein oder Quartzschiefer vom *Morro de Villa Rica* besteht aus einem graulich- " und röthlich-weissen, nich selten auch rauchgrauen, fein-und sehr feinkörnigen " Quartze und aus einem silberweissen, mehr oder weniger dunkelperlgrauen, " selten tombackbraunen, sehr zartschuppigen Glimmer, welcher nicht selten auf " den Schichtungsablösungen durch Eisenoxyd roth gefärbt ist. Der quartz " verliert zuweilen sein körniges Gefüge, und bildet schmale Schichten von " dichtem splittrigen Bruche; eben so häuft sich nicht selten der silberweisse " Glimmer auf den Ablösungen in oft einen halben Zoll dicke, wellenförmig " gebogene Schichten zusammen, und nimmt sodann einen ausgezeichneten " Perlmutterglanz an.

von Spix und von Martius, *Reise in Brasilien*, I. p. 352.

(*b*.) Granules of quartz and small lenticular masses of mica * form a pale brown or yellowish buff coloured rock; † which—both at Ouro Preto and *Gongo Soco* ‡ —succeeds the auriferous clay-slate, yet affords little or no gold.

The planes of deposition and cleavage,—parallel throughout the district,—here bear 10°–20° N. of E. & S. of W., and dip 20°–38° S.; whilst the principal joints range 10°–20° E. of N. & W. of S.

(V.) (*a*) The thick-lamellar rock which succeeds the mica-slate and conforms to its foliation, is composed, for the most part, of granular quartz and iron-ore in alternating layers; § sometimes several inches, but

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* "In many cases * * * flexures * * * involve the laminæ of which the "stratum is formed, without affecting the stratum itself."

MACCULLOCH, *Classification of Rocks*, p. 268.

Bakewell, *Introduction to Geology* (4th Edit.), p. 104.

† "Diese * * * Bildung des quartzigen Glimmerschiefers liegt auf Thon- "schiefer auf, welcher, nach seinem zu Tageausgehen in den tiefsten Puncten "des Thales von *Oiro-Preto*, die Grundlage des *Morro* auszumachen."

VON SPIX UND VON MARTIUS, *Reise in Brasilien*, I. p. 344.

"Il alterne en bancs puissants et sur une grande étendue avec le *thonschiefer*."

VON ESCHWEGE, *Annales des Mines*, VIII. p. 411.

‡ *Ante*, p. 182.

§ "*Schiste ferrugineaux (Eisenglimmer schiefer)* Les parties essentielles de "cette roche sont le fer oligiste micacé *(eisenglimmer)* et le quartz. Son tissu "est grenu-schisteaux, ordinairement lâche; on trouve cependant quelquefois "des couches solides. Le fer oligiste domine et donne à la roche une teinte de "fer oxidé plus ou moins foncée; elle est quelquefois divisée en feuillets d'une "grande ténuité: le fer et le quartz sont alors très-distincts, ce qui produit une "apparence rubanée de couleurs alternativement blanches et sombres. Les "particules de quartz sont en général peu adhérentes; elles se détachent de la "surface, qui paraît alors criblée de petites cavités: d'autres fois elles sont très- "disséminées; la masse entière prend alors un aspect tacheté. Le fer oligiste "présente le plus souvent un èclat très-vif; les fuillets minces de la roche sont "quelquefois flexibles."

VON ESCHWEGE, *Annales des Mines*, VIII. p. 413; *Pluto Brasiliensis*, p. 222.

"Man findet diese Gebirgesart" (Eisenglimmerschiefer) "hier, wie an vielen "Orten in Minas, von grosser Mannichfaltigkeit an Farbe, Dichtigkeit und

generally from one-eighth to three-quarters of an inch in thickness.

When freshly broken the quartz—slightly mixed with minute particles of iron-ore—has usually a greyish hue; exposure, however, affects the ore, and disintegrates the quartz, which becomes sandy and brown.

Of the ores, which form so large a part of this formation, specular iron — especially its micaceous variety*—is, by far, the most plentiful; oxydulated ore, however, is not uncommon; and every kind of hematite occurs, in inexhaustible abundance,† at

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"Schwere. Am häufigsten ist sie stalgrau, in alten Anbrüchten bisweilen "gelblichbraun oder ziegelroth, je nach den Oxydationsstufen des metalls. Hie "und da erscheint sie, wenn sie eine beträchtliche Menge von weissem Quartz "aufnimmt, körnig und gebändert. Diese dünnen Schichten wechseln auch "wohl mit anderen von aufgelöstem und zerbröckeltem Quartze ab. Der Gehalt "des Gesteins an Eisen ist bisweilen so beträchtlich, dass es mit Vortheil versch- "molzen werden kaun. Gold ist durch diesen Glimmerschiefer in bedeutender "Menge verbreitet."

von Spix und von Martius, *Reise in Brasilien*, i. p. 343.

Caldcleugh, *Travels in South America*, ii. p. 260 (*Ante*, p. 171). Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro, et de Minas Geraes*, i. p. 153. Walsh, *Notices of Brazil*, ii. p. 201. Gardner, *Travels in Brazil*, p. 510.

* Levy, *Description d'une collection de Minéraux, formée par M. Henri Heuland*, iii. pp. 120–1.

† "The iron smelting furnace of Dr. Roque Schüch at Timbopeba was built of "the mica-slate of the neighbourhood which contains much cyanite. The ore "which he intended to smelt was micaceous iron, some acres being covered with "it to a depth of ten yards." * * *

"At Antonio Pereira we found * * * cupreous arseniate of iron, brown iron "ore, hematite and acicular manganese. This is the locality of the specimen of "brown iron ore which contains in the centre of some scorodite a small dodeca- "hedral diamond, * * * it was purchased by Mr. Heuland of Baron "Eschwege."—Caldcleugh, *Travels in South America*, ii. pp. 262–3.

"Auch kommt überhaupt die ganze *Serra de Antonia Pereira*, ihren Bestandt- "heilen une Lagerungsverhältnissen nach, mit dem goldreichen *Morro de Villa* "*Rica* überein; denn sie besteht ebedfalls aus weissem Quarzschiefer mit Lagern "des eisenglanzhaltigen Glimmerschiefers und einer weit verbreiteten Decke "von rothem Eisensteinflötz. * * * Nordweslich von *Antonio Pereira* hat "Hr. v. Eschwege eine kleine Eisenhütte angelegt, die er durch einen deutschen

Antonio Pereira, two leagues north-east of Ouro Preto. Thin plates of mica or talc often interlie the micaceous iron-ore; and small ill-defined crystalline masses of the arseniate of iron *(Skorodite*)* sometimes stud the hydrous-oxide of iron with which interstices in the hematite are frequently lined.

The dark-coloured gold of this neighbourhood,—which averages from twenty to twenty-three carats in quality,† gives to the capital of this Province its modern name‡ of Ouro Preto.§ The purest gold in

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" Schmelzmeister leitet. Diese Fabrik berbeitet den eisenglanzhaltigen Glim-" merschiefer, der hier beträchtliche Lager auf und in dem weissen Quarzschiefer " bildet. * * * Nicht selten wird er von rothem Eisensteinflötze bedeckt. " Das Gestein ist sehr reich, von schzig bis achzig Procent."

VON SPIX UND VON MARTIUS, *Reise in Braiilien,* I. pp. 401-2.

" Les couches ètrangèrer sont * * * de fer oligiste et oxidulé, et aussi du " fer hydraté brun, * * * enfin des hématites brunes d'une grande beauté, à " couches concentriques et à rayons divergens."

VON ESCHWEGE, *Annales des Miues,* VIII. p. 414.

" The *lavaras* of *Antonio Perrira* are distant about eight miles from Villa " Rica (now called Ouro Preto), and are situated at the foot of a high mountain " running from N.N.W. to S.S.E., the surface of which is encrusted with a rich " oxyde of iron and manganese to a depth of five to fifteen feet."—EDWARDS, *Reports of the Imperial Brazilian Mining Association,* I. (1826) p. 54.

Gardner, *Ibid,* p. 55. Schüch, *Memoria sobre algumas experiencias e empenhos Mineralogicos e Metallurgicos* (Rio de Janeiro, 1840), pp. 35-50. Walsh *Notices of Brazil,* II. p. 205.

* " 4me variété. Vert-olivâtre tres-pâle, peu translucide, cristaux tres-serré " les uns contre les autres sur fer hpdro-oxidé compacte; *Antonio Pereira,* " *Brésil.*"—LEVY, *Description d'une collection de Minéraux, formée par M. Henri Heuland,* III. p. 183.

Mohs, *Treatise on Mineralogy* (English Translation by Haidinger), III. p. 150.

† " Die Minin von *Villa Rica* geben gewöhnlich ein Gold von zwanzig bis drei " und zwanzig Karat."—

VON SPIX UND VON MARTIUS, *Reise in Brazilien,* I. p. 346.

‡ " Erecta em cidade por decreto de 20 de Março de 1823, com titulo de— " *Imperial Cidade do Ouro Preto.*" *Memorias Historicas de Minas Geraes,* p. 62. Walsh, *Notices of Brazil,* II. p. 197.

§ Ouro Preto—*Black Gold.*

Minas Geraës,—twenty-three carats and seven-eighths fine,—is scattered in isolated grains through the hematite iron-ores of Antonio Pereira.

(*b.*) The high conical peak of Itabira* do Matto Dentro—a conspicuous object in the gold region— is composed, for the most part, of iron-ore and quartz in alternating layers; which—often mere laminæ, but sometimes several inches thick,—conform, in great measure, to the contour of the mountain in both direction and dip.†

(*c.*) At *Santa Anna* numberless beds, seldom more than the fraction of an inch thick, and often as thin as paper, consist, alternately, of brownish granular quartz, and of micaceous iron-glance, which—mixed at times with buff-coloured talc—passes by degrees into massive oxydulated iron ore.‡

The auriferous bed (of *Jacotinga*§), which rests conformable on these, bears nearly east and west,—dips 40°–50° south,—varies in width from six to about thirty feet,—and is composed of sandy iron-glance, earthy oxydulated iron-ore, and of brownish granular

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* "Des mots indiens *yta bera,* pierre qui brille. *Itabira* ne veut pas dire, par "conséquent, comme on l'a avancé, pierre haut et aiguë."—Saint Hilaire, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes,* I. p. 270; *O Recreador Mineiro,* I. (1845) p. 145.

von Eschwege, *Annales des Mines,* VIII. p. 419.

† Henwood, *Cornwall Geol. Trans.* VI. p. 227.

‡ von Eschwege, *Annales des Mines,* VIII. p. 417. *Ante,* p. 172, Note ‡.

§ von Eschwege, *Pluto Brasiliensis,* p. 306.

From its similarity in colour to the plumage of a well-known Brazilian game-bird *(Penelope Jacutinga).*

Henwood, *Edinburgh New Phil. Journal,* L. (1850) p. 61.

quartz, yellowish talc, and earthy oxide of manganese in smaller quantities, but often-changing proportions. Particles of gold are scattered through the formation; and those portions of it in which manganese and talc abound have been very rich. Near the surface gold often occurs in octahedral crystals,* of deep yellow colour, and exceeding purity; at greater depths, however, it frequently assumes the hue of tarnished silver, and is of inferior quality.†

The masses *(bunches)* of gold,—on which this mine has been worked to a depth of twenty-five fathoms—have an endlong dip or *shoot* ‡ towards the east.

In some places a few laminæ of quartz and micaceous iron-ore overlie the *(Jacotinga)* metalliferous bed.

(*d.*) In the *Itabira* mine similar rocks prevail;—

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* "Near the surface a considerable proportion of the gold occurs in octahedral "crystals."—Henwood, *Cornwall Geol. Trans.*, vi. p. 228.

"The greater number of rare and curious crystalline minerals occur in the "shallower portions of *lodes*, and usually where gossan is plentiful; * * * "these rarities are, however, seldom found in connection with large quantities "of ore; though other parts of the same *lodes* may be productive.—

Ibid, v. p. 206.

Becquerel, *Traité de l'électricité et du magnétisme*, iii. p. 312. Taylor, *Scientific Memoirs*, i. p. 431.

† "L'or qu'elle fournit d'abord était d'une belle couleur jaune et du titre de "23*k*. 3; mais celui que l'on trouva plus tard avait une couleur obscure. Au "reste, ce que l'on perdit par la couleur on le regagna par la quantité, et, dans "l'espace de deux mois, on retira de cette mine trois cent quaránte trois marcs" (210·87 lbs. *Troy*).

Senr. Manoel Jozé Pires da Silva Pontes; Guarda-Mór Geral.

Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes (Saint Hilaire), i. p. 273. *O Recreador Mineiro*, i. p. 146.

"L'or de quelques mines des environs de Itabira do Matto Dentro contient "communément 40 à 50 per cent. du palladium."

Claussen, *Bulletins de l'Académie Royale des Sciences de Bruxelles*, viii. (1re partie) p. 327.

‡ Henwood, *Cornwall Geol. Trans.*, v. p. 193; vi. p. 228; *Ante*, pp. 122, 200.

but mantling the peak—they range from south-east to north-west, and incline about 45° north-east.*

The metalliferous deposit is seldom less than three or more than eight feet in width; its ingredients, as well earthy as metallic, are identical with those wrought at *Santa Anna;* but its richest portions *(bunches†)*,—which have been opened as much as forty fathoms from the surface, dip or *shoot* lengthwise towards the north-west.

Many other gold-mines have been worked in the neighbourhood,‡ with more or less success.

The rocks above the *(Jacotinga)* metalliferous deposit, pass gradually into a breccia *(Tapanhoacanga;*

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* Henwood, *Cornwall Geol. Trans.*, VI. p. 227.

† "L'exploitation de l'Itabira est plus importante encore que celle de la "Conceiçaõ. Le mineral y est plus proche de la surface de la montagne, et, "pour creuser les galeries qui vont obliquement, on n'est obligé de traverser des "bancs de roche. Aucun *batéa* n'a fourni jusqu'ici plus de quatre onces d'or." * * *

"A l'époque où les fouilles du côté occidental de l'Itabira furent commencées, "un des mineurs, mécontent du résultat de ses travaux, allait abandonner ses "recherches, lorsque la chute d'un peu de terre lui fit découvrir une vein d'or si "abondante, qu'en six jours, il obtint 64 marcs" (39·34 lbs. *Troy*) "d'or avec "douze ouvriers." * * *

"Malgré la vigilance des intéressés, le pillage des ouvriers est si considérable, "que les trois quarts de l'or qui circule dans les cabarets du pays, sortent de "cette exploitation."—Senr. M. J. Pires da Silva Pontes.

Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes (Saint Hilaire), I. p. 272. *O Recreador Mineiro*, I. p. 146.

‡ "La Conceiçaõ fut exploitée par une compagnie qui réunit plusieurs centaines "d'ouvriers, et, en peu de mois, un hameau s'est élevé sur la plus affreuse mon- "tagne. A l'époque de la découverte de la mine, on avait déjà trouvé, dans une "tranchée, un gros fil d'or d'une demi-toise de longeur, qui adhérait au minerai "de fer pierreux; et, plus récemmet, une seule *bateâ* a fourni vingt-huit marcs" (17·21 lbs. *Troy*) "d'or. Ce métal se présente ici en lames fragiles plus ou "moines grandes; on le trouve aussi en grains ou en poudre d'une couleur "variable. Jusqu' à présent on a reconnu a la Conceiçaõ deux épaisses couches "minérales séparées par un lit d'une toise, et de long des mêmes couches divers

Canga)* which—in some places only a few inches, but in others several feet thick—is composed chiefly of massive brown iron-ore, irregularly mixed with quartzose iron-mica-slate, clay-slate, and quartz. The blocks, of which it is made up, are seldom more than a few inches in bigness; and most of their edges seem to have suffered decomposition or abrasion. These are cemented by indurated brown—sometimes spotted and streaked with red—iron-ore; through which grains of quartz, and—less frequently—crystalline particles of gold † are occasionally scattered.

The tools in general use are inefficient and rude, operations are therefore costly and slow. A sharpened

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" filons qui, comme elles, s'étendent dans la direction du N.E. au S.O. Dans un " intervalle de seize ans, les propriétaires ont retiré de la mine plus de vingt " mille marcs " (12,295·55 lbs. *Troy*) " d'or, et l'on peut calculer un quart en sus " pour les vols, qui sont extrêmement communs."

SENR. M. J. PIRES DA SILVA PONTES.

Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes (Saint Hilaire), I. p. 272. *O Recreador Mineiro*, I. p. 146.

* " *Tapanhoacanga* signifie, dans un idiome africain, tête de nègre: les mineurs " ont donné ce nom a la roche dont il est question, à cause de sa surface raboteuse " et qui paraît concrétionnée comme une hématite."—VON ESCHWEGE, *Annales des Mines*, VIII. (1823) p. 420. *Pluto Brasiliensis*, p. 224.

Mawe, *Travels in Brazil*, p. 303. von Spix und von Martius, *Reise in Brasilien*, I. p. 341. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. (1re partie) p. 335. Gardner, *Travels in the interior of Brazil*, p. 478. Henwood, *Cornwall Geol. Trans.*, VI. p. 228. Heusser et Claraz, *Annales des Mines*, 5me Série, XVII. p. 291.

† " Cette terre renferme de petits cristaux d'or extrêment beaux."

VON ESCHWEGE, *Annales des Mines*, VIII. p. 421.

The streets of Itabira are flooded during heavy rains; which bring from higher grounds, and deposit in crevices of the uneven pavement, quantities of earth and sandy auriferous iron-ore. These are collected and carefully washed by children, who exchange with petty shopkeepers, for bits of *(rapadura)* coarse sugar, the few grains of gold they extract.

bar of iron (the *Alabanca**) is used for splitting the harder rocks; the common miner's-pick serves to break ore of ordinary quality: whilst a somewhat pointed hoe (the *Almocafre*†) suffices for the softer ingredients.

Most of the ore obtained is carried in shallow wooden bowls (*Carumbès*‡), on the heads of negro-workmen, to the surface, through inclined openings on the dip or *shoot* of the richer masses (*bunches*) of *Jacotinga*. At *Santa Anna*, however, a small *whim*, worked by oxen, slowly raises some of the ore in buckets (*kibbles*) through a vertical shaft.§

(*e*.) A circuit of eighty miles at least is supplied with hooks, hoes, and other agricultural implements of iron manufactured at and near Itabira.‖

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* "L'*Alavanca* est une barre de fer d'environ trois à quatre pieds de longueur, "terminée d'un côté par un coin, et de l'autre par un pic en pyramide quadran-"gulaire."—Saint Hilaire, *Voyage dans l'Intérieur de Brésil*, i. p. 244.

† "On désigne sous le nom d'*almocafre* une pioche aplatie et courbée."—*Ibid*, p. 245.

Agricola, *De re Metallica* (1857), p. 110, *fig. B*.

‡ Ce mot, dans le langage des Indiens, signifie *écaille de tortue*."
Saint Hilaire, *Voyage dans l'Intérieur de Brésil*, i. p. 245.

§ Henwood, *Cornwall Geol. Trans.*, vi. p. 228.

‖ "Les forges de Girao se composaient de huit fourneaux, construits comme "celui du colonel Antonio Tomaz, et dans lequels on pouvait fondre à la fois un "arobe (32 liv.) de mêtal. Le feu était entretenu dans les fourneaux par des "soufflets pour la plupart mis en mouvement par l'eau. Comme le minerai se "trouve à Girao en masses trè-compactes, on commençait par le broyer à l'aide "d'un bocard, dont le moteur était une roue hydraulique. Une autre roue du "même genre faisait mouvoir le marteau destiné à battre le fer. La forge de "Girao entretenait environ vingt-cinq ouvriers, dont la moitié se composait d'es-"claves. Les autres, libres, et presque tous blancs, étaient nourris et recevaient "une valeur d'environ vingt sous par jour."
Saint Hilaire, *Voyage dans l'Intérieur de Brésil*, i. p. 291.

Mawe, *Travels in Brazil*, p. 296. von Eschwege, *Pluto Brasiliensis*, pp. 509–529. von Spix und von Martius, *Reise in Brasilien*, ii. p. 425. Gardner, *Travels in Brazil*, p. 482.

(*f.*) Between Morro Agudo and Pericaba the *(Itacolumite)* quartzose mica-slate is conformably overlaid by *(Itabirite)* alternating layers of iron and quartz; in which a bed of *(Jacotinga)* specular and oxydulated ore, mixed with minute quantities of grey manganese and still smaller proportions of gold,—traced more than twenty miles from north to south,—has, at *Monlevade*,* long been quarried to a width of fifty feet for smelting.

Seven Catalan furnaces and six ordinary forges are used to prepare *stamp-heads*, *strapping-plates*, *gudgeons*, *cranks*, and other heavy pieces of mining machinery.

Charcoal—the only fuel employed in the iron manufacture of Minas—made of hard wood grown on high, exposed, and stony ground, produces, from the same ore, tougher metal than that obtained from softer timber which has flourished in low, sheltered, and swampy places.†

The Brazilian—like the Castilian and Catalan—iron-smelters obtain their blasts from the fall of water through long tubes into wooden pneumatic receivers; a method long and frequently used to produce ventilation in the mines of Cornwall.‡ At *Monlevade* the

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* De Monlevade, *Annales des Mines*, IV. p. 137. Heusser et Claraz, *Ibid*, 5me Série, XVII. p. 291. *Ante*, p. 171, Note *.

† M. de Monlevade, MSS.

‡ As Pryce, who wrote in 1778, describes (*Mineralogia Cornubiensis*, pp. 146–148, 200–202) several other modes of ventilation but makes no mention of this, we may infer that it was then unknown in Cornwall.

Present enquiry when, where, and by whom this method of ventilation began to be used in the mines of Cornwall has been without avail. The following are

fall is, according to circumstances, from twenty to twenty-eight feet.*

The quartzose talc-slate of the Caraça, which con-

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amongst the earliest instances ascertained; but it is not pretended that either of them was the first:—

Date.	Mine.	Authority.
1802	*Tincroft*	William Richards, Esq., MSS.
1807 / 1812	*Dolcoath*	John Rule, Esq., „
1812	*Crowndale* (Devon)	Captain James Holman, „
	United Mines	Captain Simon Davey, „
1814	*Wheal Abraham* / *Crenver*	Nicholas Vivian, Esq., „
1817	*North Roskear*	Joseph Vivian, Esq., „

"Lorsque l'on a à sa disposition une chute d'eau de 3 à 4 mètres au moins "hauteur, on peut l'utiliser pour établir une *trompe*, qui sera placée prés de "l'ouverture d'entrée de l'air dans la mine. * * * La construction de la "trompe, est d'ailleurs assez généralement connue. * * * Elle se compose "d'un canal, qui amène l'eau; d'un arbre foré, recevant l'eau par sa partie "supérieure, et posé sur le fond supérieur d'une caisse ou barrique, ouverte par "le bas, et plongée dans une fosse remplie d'eau; d'une plaque de fonte appelée "*tablier*, sur laquelle se brise l'eau tombant par l'arbre creux; et d'un porte-vente "ou conduit implanté sur le fond supérieur de la caisse, par lequel l'air dégagé de "l'eau est amené dans le puits ou galerie d'entrée de l'air. L'arbre creux est "terminée à sa partie supérieure par une espéce d'entonnoir, appelé *étranguillon*. "Quatre trous, nommés *aspirateurs*, sont percés immédiatement au-dessous de "l'étranguillon et permettent l'entrée de l'air atmosphériquc qui est entraîné par "l'eau. Dans la trompe de *Rancié*, l'arbre creux avait un diamètre intérieur de "$0^{m}\cdot22$" (8·66 inches); "l'étranguillon, un diamètre de $0^{m}\cdot15$" (5·90 inches). "La hauteur de la chute, depuis le seuil du canal qui amenait l'eau jusqu' au "tablier, était de $8^{m}\cdot61$" (33·89 feet); "le volume d'eau motrice de 40 à 50 litres" (1·437 to 1·796 cubic feet) "par seconde. L'air pouvait être comprimé dans la "barrique, de façon que l'excès de sa pression sur la pression atmosphérique "fût mesuré par une colonne d'eau de $0^{m}\cdot85$" (2·79 feet), "ou par une colonne "de mercure de $0^{m}\cdot062$" (2·44 inches) "de hauteur. La vitesse de l'air sortant "sous une telle compression était de 114 mètres" (374·02 feet) "par seconde."
Daubuisson, *Annales des Mines*, 2me Série, iv. (1828) pp. 211-213.

Thibaud et Tardy, *Ibid*, 1re Série, viii. (1823) pp. 295-628. Héron de Ville-"fosse, *De la Richesse Minérale*, Pl. xlix. fig. 10-14 (1819). Combes, *Traité de l'Exploitation des Mines*, ii. pp. 504, 505. Henwood, *Extracts from the Records of Government* (Calcutta, 1855), p. 41. Mackworth, *Report of the Royal Cornwall Polytechnic Society* (1856), p. 80. Scoffern, *The Useful Metals and their Alloys* (1857), p. 33. Truran, *Ibid*, p. 138.*

* M. de Monlevade, MSS.

tains gold at *Santa Rita*,* is succeeded by thin alternations of quartz and iron-ore,† exactly resembling those at *Itabira*,‡ *Santa Anna*,§ *Monlevade*,‖ *Corrego de Saõ Miguel*,¶ *Cocäes*,¶ and *Gongo Soco*.¶

Maintaining a general parallelism to the mountain-side, they range 10° W. of N. & E. of S. through a succession of picturesque hills; which at *Boa Vista*, *Pitangui*, *Morro das Almas*, *Agoa Quente*, *Piracatú*, *Pissarraõ*, *Fazendaõ*, and *Duraõ*, are deeply scarred by the *(Cattas**)* works of ancient gold-miners.

Although this formation is nowhere utterly destitute of gold, those parts only of it are wrought, which—limited in some places to the beds, but in others to the joints,—consist of crystallized specular iron, mixed with smaller quantities of grey manganese, talc, earthy brown iron-ore, and quartz.

(*g*.) At *Boa Vista* granular quartz, and specular iron-ore sometimes of lamellar sometimes of crystalline structure, alternate in thin beds; which—dipping 40°–46° E.—range 10° W. of N. & E. of S. in some places, but N. and S. in others.

The ore—chiefly iron-glance, quartz, and talc, the refuse of former operations—is conveyed by hand in shallow wooden bowls *(Carumbés)*, from even the

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* *Ante*, p. 180.

† "A *Cattas Altas* il y a des lavages considérables. A *Corvos* il en existe aussi "beaucoup, dont un rapporta il y quelques années, en un seul mois, un bénéfice "net énorme de 19,200 fr. (£764), en y employant seulement quatre nègres."
MAWE, *Annales des Mines*, II. (1817), p. 216.

‡ *Ante*, p. 216. § *Ante*, p. 214. ‖ *Ante*, p. 219. ¶ *Postea*.

** "On appelle ainsi" *(Cattas)* "les excavations faites par les anciens mineurs."
SAINT HILAIRE, *Voyage dans l'Intérieur du Brésil*, I. p. 188.

deepest pits, to the *(Rancho)* washing-shed; where small quantities of gold are separated from it by slaves, whose working-dresses are merely loin-cloths, cotton rugs, and straw hats.

(*h.*) At the foot of a high and glittering cliff of specular iron-ore deeply scarped by the works of ancient miners, *Pitangui* * is wrought, to a depth of about ten

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* "The mine of Guarda Môr Innocencio is a large excavation in the side of a "range of grotesque mountains" (the Caraça). "The upper stratum is red "ochrey earth of about twenty feet thick; underneath follows the ferro-mica- "ceous slate, with sand between the laminæ, which exactly resembles the ore "smelted at Timbopeba; and, below that, compact magnetic or oxydulated iron- "ore. These lower beds were traversed by veins of ferruginous quartz, in im- "mediate contact with which there was in most cases some specular iron in thin "laminæ. The gold existed in the quartz veins which were thin; but several "nearly three feet across had been just covered up by a fall of the upper stratum." * * *

"The quartz veins alone are consigned to the stamping mill." * * *

"The larger masses are split by means of fire."

"From this *lavra* I proceeded to another of exactly the same formation; the "iron, however, containing a little gold, is stamped as well as the quartz."

Caldcleugh, *Travels in South America*, II. p. 282.

"Diese Goldmine wird schon seit achtzig Jahren, und zwar früher mit sehr "vielen, jetzt nur mit achtzig Negern betrieben. Auf dem weissen Quarzschiefer, "der den Hauptstock des ganzen Gebirges bildet, liegt hier ein mächtiges Lager "des eisenhaltigen oder sogenannten Eisenglimmerschiefers, welches, in einer "Höhe von dreissig bis vierzig Klaftern entblösst, steile, stahlgraue Wände "darstellt. Diese Gebirgsart besteht aus einem feinkörnigen, rauchgrauen "Quarze, und stahlgrauen, feinkörnigen Eisenglanze, der die Stelle des gemeinen "Glimmers vertritt. Gewöhnlich ist sie dünn, selten bis zu einem Fuss dick "geschichtet, oft bei grossem Quarzgehalte fast zerreiblich, und auf den "Ablösungen mit gelblich braunem Eisenocker überzogen. Hie und da kommt "darin grossblättriger, meistens wellenförmig gebogener, derber Eisenglanz vor. "Der sogenannte Eisenglimmerschiefer streicht in Stunde 22 von Süden nach "Norden, und fällt unter Winkeln von 50° bis 80° nach Osten. Mehr oder "weniger vom Quarze abgesondert kann sein Eisengehalt fünfzig bis siebenzig "Procente betragen. Man bemerkt Uebergänge in reinen Eisenglanz, häufiger "aber noch in den Quarzschiefer, der die Hauptformation ausmacht, und dem "er nur als mächtiges Lager untergeordnet ist. Gegen den Gipfel des Berges "hin wird diese Bildung von der, bereits bei Villa Rica beschriebenen Eisen- "steinflötzformation bedeckt, in welcher grosse Stücke von Eisenerzen, die bei "dem Goldwaschen nicht zerstossen werden können, werden von den Negern auf "dem Kopfe aus der Mine getragen, und längs dem Berge vor dem Hause in

fathoms, or two series of auriferous *lines;* of which, one—parallel to the cleavage of the neighbouring rock—ranges from N.E. to S.W., and inclines 48°–65° S.E.; the other—conforming to one series of its joints—bears about S.E. & N.W., and dips 62°–78° N.E. Partaking, as usual, the mineral character of the adjoining formation, they alike consist of specular and earthy brown iron-ore mixed with smaller quanties of manganese, talc, and quartz. The particles, threads,

Fig. 16. PITANGUI.
Alternating bands of gold and its matrix (natural size).

"einen hohen Wall anfgeschichtet, der die grössten Schmelzwerke Jahre lang "zu beschäftigen im Stande wäre. Das Gold ist von goldgelber Farbe, und "kommt zwischen dem Eisenglimmerschiefer in feinen Körnern vor, die viele "einzelne Krystallisationsflächen zeigen, und bisweilen so an einander gewachsen "sind, dass sie mehrere Zoll lange, dünne, röhrenförmige, an einander stossende "Reihen bilden. Auch im Eisensteinflötze und im Quarze kommt Gold vor, "mehr aber noch auf den Ablösungen des derben Eisenglanzes selbst. Ein "mächtiger Bach fällt zur Regenzeit aus dem oberen Theile des Berges in die "hinterste Schlucht, welche das Eisenglimmerschieferlager bildet, bringt die, "aus dem Eisensteinflötz auf der Höhe des Berges losgerissenen Goldtheilchen "mit sich, und wäscht den Schlich aus dem zerreiblichen Eisenglimmerschiefer "ebenfalls durch. Ein Theil desselben wird in einen, unterhalb der Fazenda "vorgerichteten Teich herabgeführt, und hieraus das edle Metall mittelst der "Pateas ausgewaschen. Beim Schmelzen erhält das hiesige Gold, wahrscheinlich "durch die beträchtliche Beimengung von Braunstein, Arsenik und Spiessglanz."

VON SPIX UND VON MARTIUS, *Reise in Brasilien,* I. pp. 404–5. VON ESCHWEGE, *Pluto Brasiliensis,* p. 18.

and flakes of gold—obedient, perhaps, to some influence of the strata—are arranged in parallel bands; which alternate with corresponding stripes of the matrix, and dip *(shoot)* east from the granite* *(fig.* 16*)*.

Negroes carry the ore in bowls on their heads to the surface.†

(*i.*) The works at *Morro das Almas* present a precipice of specular iron-ore, higher and broader than that at *Pitangui;* but the auriferous laminæ it contains are irregular and poor. Although they have long been abandoned, heavy rains still strip from them, and deposit in the Corrego da Cangîca, an abundance of ore; from which a few poor people extract, by stealth, trifling quantities of gold.

(*j.*) At *Agoa Quente*‡ the ancient open-works are much smaller, but the modern mining operations which have intersected a great breadth of iron mica-slate are far more extensive than those at *Pitangui* and *Boa Vista.*

(1.) The specular and oxydulated ore and the quartz of which *(Itabirite)* iron mica-slate is chiefly composed commonly form alternate layers of small but uniform thickness. These are usually persistent; but now and then a band—indifferently of either ingredient—dwindles and disappears (*Fig.* 17); at intervals masses and laminæ of one mineral are enveloped in strata of the other; sometimes the materials—though

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* *Ante*, p. 176.

† Henwood, *Cornwall Geol. Trans.*, vi. p. 228; *Ante*, p. 218.

‡ "At Agoa Quente an old man remembered the water which had issued luke-"warm from the mine; but which had lately been covered up by a fall of earth."
Caldcleugh, *Travels in South America*, ii. p. 283.

in unequal proportions—are thoroughly mixed; and not uncommonly octahedral crystals of oxydulated ore are imbedded in specular iron.

Between beds of different mineral character crevices are numerous; some of these are several fathoms in length and height, but few are more than a couple of lines and none exceed two inches in width. Quartz,—here and there crystalline and enclosing at times crystals of titanite,*—often either porous or cellular, but as frequently specular,—is plentiful in some of them; the hydrous oxide of iron hangs in stalactites from the roofs and forms tuberculated crusts on the floors of others; whilst an earthy yellowish-brown iron ochre fills the rest.

Some of the joints are filled with angular masses of specular ore and ferruginous quartz, cemented by hydrous oxide of iron and imbedded in similar ochre.

At some distance above the mica-slate, but beneath the *(Jacotinga)* auriferous beds, the alternating strata

Fig. 17. AGOA QUENTE or BANANAL.

Alternating layers of quartz and of iron-ore, displaced by small quartzose cross-veins.

(Natural size.)

* De Monlevade, *Annales des Mines*, IV. (1819) p. 136. Levy, *Description d'une collection de Minéraux, formée par M. H. Heuland*, III. p. 339.

of iron-ore and of quartz are, at short intervals, obliquely traversed by veins of quartz; which—seldom exceeding half, and generally less than a quarter, of an inch in width—have neither a horizontal nor a vertical range of more than a few feet.* These, however small, so dislocate all the beds they intersect, that each severed portion occupies a higher relative position in the upper *(hanging-wall)*, than its counterpart in the *(foot-wall)* lower, side of the *cross-vein* (*Fig.* 17).† The extent of displacement *(throw)*—rarely exceeding half an inch—is greatest at the middle of every *cross-vein;* but—gradually diminishing towards either extremity,—is, at length, barely perceptible.* Beyond the range of each intersection, however, the rocks—

* "Some cross-veins seem peculiar or confined to certain *lodes*, and do not "extend to parallel ones, however near; whilst others appear only at certain "levels on a single *lode*, and disappear upwards, downwards, and at either end."
Henwood, *Cornwall Geol. Trans.*, v. p. 381; *Ante*, p. 125.

† At *Wheal Peever* the tin-*lode*, underlaying south, is traversed in its downward course by two *slides*, both underlying north;—
in one case the part of the *lode* in the upper side (*hanging-wall*) of the *slide* is 18 fms. higher,—
in the other „ „ „ „ „ $1\frac{1}{2}$ fm. lower,
than the respective counterparts in the opposite sides *(foot walls)* of the *slides*.

These interesting intersections—described by John Williams, Jun., Esq., F.R.S., *Geol. Trans.* iv. (1813) p. 144, Pl. VII. fig. 2; Richard Thomas, Esq., C.E., *Survey of the Mining District between Chacewater and Camborne* (1819), pp. 23, 61, Section IX.; Joseph Carne, Esq., F.R.S., F.G.S., *Cornwall Geol. Trans.*, ii. (1819) p. 20, Pl. II. fig. 2; John Hawkins, Esq., F.R.S., *Ibid* (1820), p. 238, Pl. IV. fig. 4,—were surveyed and figured in 1803 by the late Benjamin Sampson, Esq., of Tullimaar.

"The down-slides are * * * the most frequent * * * about Redruth and "Gwennap; but in St. Agnes, the lodes are generally started upward."
Hawkins, *Cornwall Geol. Trans.*, ii. p. 241.

"At *South Wheal Towan* the *lode* in the lower *(foot wall)* occurs at a higher "level than in the upper side *(hanging wall)* of the *slide*."
Henwood, *Proceedings of the Geol. Soc.* i. (1832) p. 405;
Cornwall Geol. Trans. v. p. 331, Pl. VII., fig. 15.

"At *Herland*, *Bull's* or *North Herland lode* is found at a lower point in the "lower *(foot-wall)* than in the upper side (*hanging-wall*) of the *slide* which inter-

maintaining their normal positions—exhibit no sign of disturbance.

(2.) Within a short distance of its upper boundary, the *(Itabirite)* iron mica-slate contains, for a few fathoms in breadth, an unusually small proportion of quartz; which is, for the most part, mixed, rather than interlaminated as elsewhere, with the ore. Mica, however,—disposed in the ordinary manner—is, on the contrary, more than commonly abundant.

The beds—in some places much coarser than in others, yet everywhere of granular texture—bear 10°–15° W. of N. & E. of S., and on the north dip—as at *Boa Vista, Pitangui,* and *Morro das Almas*—40°–52° E.; towards the south, however, they gradually assume a higher inclination, and at length dip 62°–76° W.

(3.) These are the only productive beds at *Agoa Quente;* and it is in limited portions, even of them, that gold abounds. The richer parts—conforming to the cleavage, and partaking, in some measure, the nature of the rocks they interlie—consist chiefly of specular and micaceous iron-ore; of which certain

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" sects it."—Henwood, *Proceedings of the Geol. Soc.*, I. (1832) p. 405; *Cornwall Geol. Trans.*, v. *Table XXXIV.*

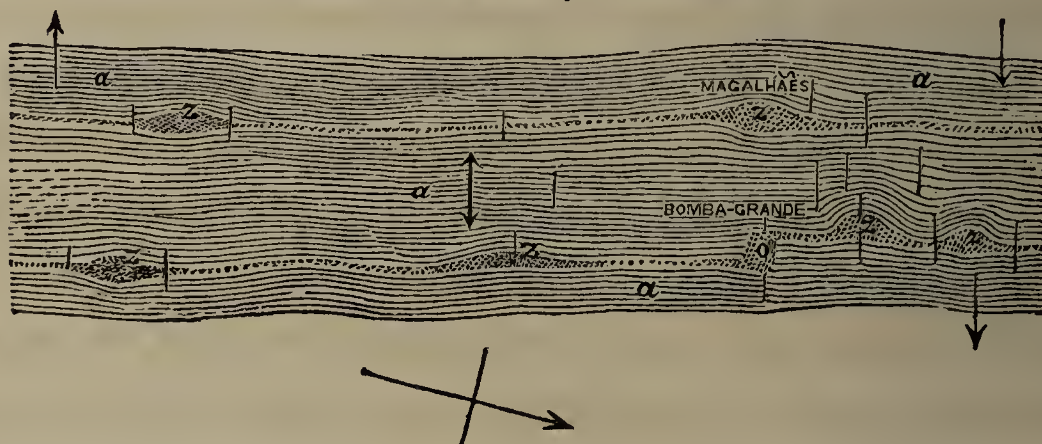
" The *slip* or plane of dislocation hades, dips, underlays, or is inclined * * * " so as to pass under the depressed portion of the strata which are displaced. " * * * In some hundred instances of dislocation *I have never seen the con-* " *trary.*"—Professor Phillips, *Illustrations of the Geology of Yorkshire*, II. (1836) p. 111, Pl. XXIV., figs. 16, 17. *Ante*, p. 72, Note.

Pryce, *Mineralogia Cornubiensis*, p. 106. Forster, *Section of the Strata from Newcastle to Cross Fell*, pp. 191, 262. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836), pp. 90, 97. Leithart, *Mineral Veins.* Prestwich & Morris, *Quarterly Journal of the Geological Society*, IV. (1846) p. 402. De la Condamine, *Ibid*, VIII. (1852) p. 193. Wallace, *On the laws which regulate the deposition of Lead-ore in Veins*, p. 82, Pl. VII.

neighbouring, and generally parallel, laminæ are here and there unconformably deflected; but—resuming their ordinary direction and dip—within short distances they re-approach and again coincide. Some of the lenticular spaces thus included are no more than a few inches, but others are several feet in length and depth; none, however, exceed eighteen, and most of them are less than four, inches wide; whilst many are still smaller.

AGOA QUENTE or BANANAL.

Fig. 18. *Horizontal Section of the Jacotinga.*



a. Laminæ of specular and micaceous iron-ore.
o. Auriferous deposit on a *cross-vein.*
z. Auriferous masses of (*Jacotinga*) brown iron-ore, manganese, talc, quartz, and oxydulated iron.

Within these smooth undulating boundaries (*Fig.* 18, *a.*),—quartz in unequal, but sometimes in large proportions,—minute crystals of oxydulated and titaniferous ore in constant abundance,—together with scales of micaceous iron, flakes of talc, and nests of felspar-clay less uniformly distributed and in smaller numbers,—are imbedded in a matrix of earthy brown iron-ore (*z.*); of which every joint and crevice is slightly tinged with manganese.

Crystals of oxydulated iron-ore and quartz,—though

large ingredients in these deposits,—seldom or never enclose, yet are often imbedded in, gold. Laminæ of talc and of micaceous iron-ore, on the contrary, alternate with leaves of gold, many of which are no thicker than paper. But of the various modes in which gold is distributed elsewhere, few have been unnoticed in some part or other of the earthy brown iron-ore, which is here its most general and most congenial matrix.

Beneath extensive works of early gold-miners which score the *Morro da Agoa Quente*, many ill-directed holes spread in different directions from a ragged-sided pit, which, measuring twenty-four fathoms by twelve at the top, and four fathoms square at the bottom, is about nine fathoms deep.* From a shaft sunk in the north-eastern corner of this pit, and from other shafts near it, two auriferous formations have been wrought to a depth rather exceeding thirty fathoms from the surface.

(3—*a.*) The *Magalhães*, or western bed, maintains throughout a range 10°–15° W. of N. & E. of S.; but one part,—conforming to the rocks adjoining,—dips ... 50°–70° E.;—
whilst another, scarcely sixty fathoms distant, „ ... 62°–76° W.†

But, whether the dip be easterly or westerly, the width—generally less than one inch—never exceeds six inches.

Each of these oppositely-inclined portions of the same bed contains, at nearly the same depth, a small deposit (*bunch*) of gold. (*Fig.* 18, *z.*)

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* Henwood, Blamey, Pengilly, Luke, and Hitchens, *Reports of the Imperial Brazilian Mining Association*, XLIII. (1847) pp. 1–7.

† *Ante*, p. 227.

Northern or Magalhães bunch.

Depth. fms.		Width of bed. ins.		Proportion of gold in the ore.
10	....	4·0—6·0	....	0·012773
13	....	4·0—6·5	....	0·005739
18	....	1·0—2·0	....	0·002017
20	....	0·7—1·0	....	Thinly sprinkled with gold.
21	....	0·5—0·7	....	Traces of gold.
28	....	0·5—0·7	....	Slight traces of gold.

Southern bunch.

Depth. fms.		Width of bed. ins.		Proportion of gold in the ore.
14	....	6·0	....	0·008067
21	....	1·0—2·0	....	Very thinly spotted with gold.

Talcose clay is largely mixed with the other ingredients; * and, towards the south, small crystals of titaniferous iron-ore are not uncommon.

(3—*b.*) The *Bomba Grande* formation conforms to the rocks on either side, dips 45°–72° E.; and—often a mere line, though at times as much as eighteen inches,—is seldom more than two inches, wide. In the poorer parts it is not always easy to ascertain which of several divergent talcose faces represents the metalliferous bed. The richer portions (*Fig.* 18, *z.*), which never exceed a few feet in length, though they are generally several fathoms in depth, consist—as already mentioned *—of iron-ore, talc, felspar, and gold. Two of the largest (*bunches*) masses (*z. z.*) contained gold in the following proportions:—

* *Ante*, p. 227.

Northern Bunch.

Depth. fms.	Width of bed. ins.	Proportion of gold in the ore.
20	1—4	0·002598
,,	3—4	0·006015
25	3—4	0·006648
27	2—4	0·000379
28	1—2	0·005217
,,	2—4	Thinly spotted with gold.
34	2—3	Very thinly spotted with gold.
38	3—6	At intervals thinly spotted with gold.
39	1—2	Slight traces of gold.

Southern bunch.

Depth. fms.	Width of bed. ins.	Proportion of gold in the ore.
11	12—14	Very thinly spotted with gold.
,,	2—3	Thinly spotted with gold at intervals.
20	4–6	0·016988
21	6—8	0·008897
,,	7—10	0·008864
,,	2—3	At intervals thinly spotted with gold.
,,	Several seams each less than 1.	Thinly sprinkled with gold.
24	3—6	0·011975
,,	3—5	0·007091
,,	3—6	0·606944
25	3—4	0·000823
,,	3—4	0·001703
,,	4	0·004518
,,	3—4	0·005187
,,	2—3	0·008705

Southern bunch continued.

Depth. fms.	Width of bed. ins.	Proportion of gold in the ore.
25	4—6	0·013674
29	2—3	0·004384
33	4—7	0·003286
35	2—4	0·005794
,,	1—3	0·004787
,,	2—3	0·000419
,,	3—4	Spotted with gold.
,,	2—3	Thinly sprinkled with gold at intervals.
38	2—3	Sprinkled with gold.
39	1—2	,,
41	1—2	0·001774
,,	1—2	Very thinly sprinkled with gold.

(3—*c*.) Midway between these *(bunches)* masses a *cross-vein* (*Fig.* 18, *o*)—bearing 10°–20° N. of E. & S. of W., and dipping 45°–58° N.—traverses the iron-slate, nearly at right-angles, but deflects the auriferous *(jacotinga)* bed towards the *left-hand.** Whilst intersecting the iron-rock it is a simple seam of quartz from two to four inches in width; but divides into *branches* when accompanying the *jacotinga;* which, when unproductive, is often highly siliceous.

At twelve fathoms deep the deflected part formed, with the accompanying *cross-vein,* a mass twelve feet long and eighteen inches wide; which towards the sides consisted chiefly of quartz, and was there wholly unpro-

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* *Ante*, p. 23.

ductive; the central portions, however, were in great measure made up of earthy brown iron-ore,* flecked with talc, and mixed with small quantities of micaceous and oxydulated iron; these were thickly, though irregularly, sprinkled with masses, particles, veins, and threads of gold.†

At a depth of fourteen fathoms the relations and ingredients of this mass were unchanged; but it scarcely exceeded seven feet in length or fourteen inches in extreme breadth; whilst the auriferous part was no more than from an inch to two inches wide.‡

At sixteen fathoms from the surface it was only four feet long, but the productive seam averaged three inches in width.§

From seventeen to twenty fathoms deep it was between five and six feet long; and the *jacotinga*—yet bounded by quartz at the sides—was, for a width of three or four inches, still rich in gold.

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* *Ante*, p. 227.

† Henwood, *Reports of the Imperial Brazilian Mining Association*, XLIII. (1847) p. 3.

‡ *Ibid*, p. 3.

"At about fourteen fathoms from the surface in the mine of *Agoa Quente* "we sunk about six or eight inches on part of a rich vein from four to six feet "in length and an inch to three inches in width, and the ore we extracted con-"tained about ten pounds (Troy) of gold."

BLAMEY, PENGILLY, & LUKE, *Ibid*, p. 4.

§ "Operations are carried on by sinking in micaceous iron slate, on a line "about three inches wide, composed of iron, manganese, quartz, and gold. From "the richest part of it, which is from three and a half to four feet long, I took "two hundred-weight of ore, which produced" (1·936 lb. Troy) "201½ *oitavas*" (0·007110 its weight) "of gold. * * * On another occasion I took from the "same vein three hundred-weight of ore, which produced" (4·803 lbs. Troy) "500 *oitavas*" (0·011762 its weight) "of gold, besides several small but very "good specimens which were not weighed."—HITCHENS, *Ibid*, p. 6.

From twelve to twenty-three fathoms the quartz and *jacotinga* maintained their peculiar positions; whilst the adjoining rocks consisted chiefly of iron-ore. At greater depths, however, the strata assumed, gradually, a more siliceous character: masses of auriferous *jacotinga* were, for some distance, irregularly scattered through the quartz; but as the ingredients were, by degrees, more thoroughly intermingled, gold became proportionally scarce.

Between twenty-five and thirty-one fathoms the deflected mass was but four feet long by three or four inches wide; and deeper portions were still smaller. Earthy brown iron-ore, the most congenial matrix,—gradually diminishing—at last disappeared; and the formation, then composed of micaceous iron and quartz only, afforded scarcely a trace of gold.*

The deflected *jacotinga*—conforming to the *cross-vein* which deflects it, and thus underlying 45°–58° N. —intersects many of the neighbouring strata; † but consists of kindly *vein-stone* only whilst it traverses those shallower parts of them which are composed chiefly of iron-ore. The auriferous *(bunch)* portion, obedient, perhaps, to some influence of the adjoining rocks, coincides with their dip from the granite,‡ and *shoots*, endlong, 40°–50° towards the E.

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* *Reports of the Imperial Brazilian Mining Association*, LI. (1851) p. 2.

† *Ante*, p. 232.

‡ Henwood, *Cornwall Geol. Trans.*, v. p. 193; VI. p. 146: *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, XXV. (1844) p. 353. *Ante*, pp. 32, 125, 207.

Bomba Grande (deflected) jacotinga (Fig. 18, o).

Depth. fms.		Width of bed. ins.		Proportion of gold in the ore.
12	......	1—5	.....	0·017232
14	......	1—2	.....	0·017479
16	......	3	.....	0·007110 * / 0·011762 *
17	......	3—4	.....	0·008262
18	......	3—4	.....	0·015184
20	......	2—3	.....	0·004377
25	......	4—6	.....	Spotted with gold.
27	......	3—4	.....	Thinly sprinkled with gold.
31	......	2—3	.....	Scarcely a trace of gold.†

The following monthly returns,‡ made whilst *Agoa Quente* was worked by the Imperial Brazilian Mining Association, show the irregular distribution of gold in adjoining masses of *jacotinga.*

	1847.	1848.	1849.	1850.	1851.	1852.	1853.
Jan.	—	—	11·609	43·387	6·321	3·154	0·587
Feb.	—	3·138	35·338	6·750	10·658	0·900	—
March ..	—	—	16·813	5·804	8·333	2·200	—
April....	—	—	15·283	33·804	6·067	2·604	0·471
May	—	—	11·175	48·462	10·454	1·575	—
June....	—	—	59·712	5·338	7·988	1·338	0·471
July	24·550	11·025	6·186	15·817	3·987	0·939	—
Aug. ..	26·358	62·142	8·275	16·279	1·504	1·355	0·150
Sept. ..	—	32·796	2·725	19·567	2·392	0·502	—
Oct. ..	—	30·829	9·604	27·575	3·721	0·228	—
Nov. ..	—	16·496	12·954	6·408	3·342	—	—
Dec. ..	15·582	17·545	53·288	9·255	0·492	—	—
	66·490	178·471	242·962	238·446	65·259	14·795	1·679

Total.... 808·102 lbs Troy.

* *Ante*, p. 233, Note §. † *Ante*, p. 234, Note *.

‡ *Reports of the Imperial Brazilian Mining Association*, XLIV. (1848) p. 7; XLV. p. 7; XLVI. p. 10; XLVII. p. 7; XLVIII. p. 6; XLIX. p. 9; L. p. 7; LI. p. 10;

(4.) The gold of *Agoa Quente* seldom exceeds twenty-two carats fine, and silver is its only alloy.*

(*k.*) At *Piracatú*, *Pissarraõ*, and *Fazendaõ*, south of *Agoa Quente,* the iron-slate—still parallel to the Caraça—ranges 5°–10° E. of N. and W. of S; but, though often examined, it has hitherto yielded no gold.

(*l.*) Further southward, however, the same formation — covered with a crust of *Canga* † — contains, at *Duraõ*, nests of *jacotinga* interspersed with particles of native copper ‡ and, yet more sparingly, with small crystals of gold.

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lii. p. 7; liii. p. 18; liv. p. 16; lv. p. 13; lvi. (1854) p. 9. Hunt, *Lectures on Gold*, p. 201.

* "The gold of *Agoa Quente*, which is from 21·3 to 22 carats fine, affords no "trace either of palladium or of copper, but is alloyed with silver only."

Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., MSS.

von Eschwege, *Pluto Brasiliensis*, p. 298. de Saint Hilaire, *Voyage dans l'Intérieur du Brésil*, i. p. 187.

† von Eschwege, *Pluto Brasiliensis*, p. 224. *Annales des Mines*, viii. (1823) p. 420. *Ante*, p. 217, Note.

Entre le hameau de *Morro d'Agoa Quente* et Inficionado, "nous traversâmes "un terrain entièrement ferrugineux, couvert de bois, et nous y recueillîmes un "grande nombre de belles plantes, principalement de sapocynées. Nous ob- "servâmes qu'n général les terrains de cette nature sont ceux qui offrent la "végêtation la plus variée. Les plantes y sont ordinairement moins vigoureuses "qu'ailleurs, mais elles ne contiennent pas, à beaucoup près autant de parties "aquenses. Certains végétaux indiquent presque avec certitude la présence "du fer, et, parmi eux, on doit citer principalement trois espèces de quinquina à "tige fort grêle, qui étant très-voisines, sont confondues par les habitans sous le "nom de *quina da Serra* ou de *Remijo*, et qu'ils emploient avec succès comme "fébrifuges (*cinehona ferruginea*, *Vellozii*, *Remijiana*, Aug. de Saint Hil.)."

de Saint-Hilaire, *Voyage dans l'Intérieur du Brésil*, i. p. 187.

‡ "Eine Stunde" von Inficionado, "nachdem man eine bergigte Gegend, die "Serra de Tapanhoacanga genannt, überschritten hat, woselbst das Eisen-Con- "glomerat die ganze Oberfläche wie eine gepflasterte Tenne überzieht, kommt "man dicht am Fusse der hohen Serra do Carassa, von der meine Freunde, v. Spix "und v. Martius, in ihren vortrefflichen Reisebemerkungen genauere Nachrichten "geben, nach der Fasenda des Capitaõ Duraõ, der wie bei der Geschichte des

(*m.*) Immediately south of the Periçicaba, a broad band of micaceous iron is largely charged with octahedrons of oxydulated ore; but it affords no gold.*

(*n.*) The ancient (*talho aberto*†) open-work ‡ of *Catta Preta* reaches, from within half-a-mile of the river, some eight hundred fathoms lengthwise towards the south; but is no more than a few feet wide in some places, though as much as forty fathoms in others.

The lamellar structure prevalent throughout, is unequally developed in different parts of the (*Carvoeira* §)

"Eisens bemerkt werden wird, der erste war, welcher Eisen schmolz, und den "gediegenen Kupfersand entdeckte."

VON ESCHWEGE, *Pluto Brasiliensis*, p. 298.

"The richest portion afforded,—

"Copper	85·
"Gold	7·
"Oxydulated iron-ore (sand)	8·
	100·"

PERCIVAL NORTON JOHNSON, ESQ., F.R.S., F.G.S., &c., MSS.

Henwood, *Edin. New Phil. Journal*, L. (1851) p. 63.

* Henwood, *Reports of the Imperial Brazilian Mining Association*, XLI. (1846) p. 10.

† "*Talho Aberto*;—travail à ciel ouvert."

DE SAINT-HILAIRE, *Voyage dans l'Intérieur du Brésil*, I. p. 243.

‡ "The *lavras* of *Catta Preta*, *Catta Velha*, and *Catta Grande* are amongst "those that were first worked by the *Paulistas* (natives of *Saõ Paulo*) about the "year 1690."—GARDNER, *Reports of the Imperial Brazilian Mining Association*, II. (1826) p. 69.

"From an excavation about one hundred *palmas*" (12 fathoms) "long in "front of the house Colonel Manoel Fernandes de Oliveira in the years 1716–7 "extracted 20,800 oitavas" (199·803 lbs. Troy) "of gold."

DA GAMA, *Ibid*, p. 67.

"When a late Captain General of the Province visited *Catta Preta* with his "*suite*, a plate containing several specimens of gold from the mine, was, in place "of dessert, set before each guest."

CAPTAIN MANOEL JOZÉ FERNANDES DE OLIVEIRA, MSS.

§ "Bei Inficionado findet man die sonst so berühmte Lavra da Catta Preta. "Das Muttergebirge der Goldformation ist hier eine schwarze thonigte und

formation thus wrought; yet, conforming to the

"talkigte bituminöse zerreibliche und schmierige Masse, deren verticale Schichten "in der Isten Stunde ihr Streichen haben, und am Fusse des höheren Gebirges "mit demselben parallel fortlaufend sind. Diese schwarze Masse enthält hier "und da grosse Blöcke von Magneteisenstein, dichtem und spieglichten Eisen-"glanz, den man vorzüglich schön auch in demselben in doppelt vierseitigen "Pyramiden von der Grösse einer welchen Nuss und darüber crystallisirt findet. "Dieses Vorkommen grosser isolirter Felsenstüke von Eisensteinmassen in der "weichen schwarzen Gebirgsmasse, bleibt immer sehr merkwürdig, da hier "schlechterdings von einer neueren Anschwemmung die Rede uicht seyn kann, "und die Gebirgsschichten zu beiden Seiten des Goldlagers, welches in das "Nebengestein vorkommende Uebergänge macht, in dem es sich durch nichts "als die Farbe unterscheidet, von demselben Alter der Urformation zu seyn "scheinen. * * * * * *

"Parallel mit den Gebirgsschichten laufen in dieser schwarzen Thon-und "Talkmasse Streifen eines mürben eisenschüssigen Quarzes, der vorzüglich gold-"haltig und reich ist. Diese Streifen, die als die wahre Gold-Formaçâo angesehen "werden, sind nicht über einige Zoll stark, erreichen zuweilen ihr Ende, ziehen "sich in Nestern zusammen, und setzen dann zusammenhängend weiter fort, so "wie auch vertical in die Tiefe nieder. Geologisch merkwürdig auf diesem "Quarzstreifen ist das Vorkommen vollkommener abgerundeter Quarsgeschiebe, "und der Bergmann will die Bemerkung gemacht haben, das wo diese erscheine, "die Formaçâõ goldreicher ist. * * * *

"Die schwarze Talkerde enthält auch sehr vielen Arsenikkies, den man hier "Antimonium zu nennen pflegt, als feinen Staub beigemengt. * * * "Auf 70 Palmen" (8·4 fathoms) "tief hat man in der Formaçâõ an manchen "Stellen niedergearbeitet und aufserordentlich viel Gold gewonnen, allein da die "Quellwasser zu stark waren und die Gebirgsarten zu weich, so waren erstere "nicht mehr zu Sumpf zu halten, und letztere verstürzten immer die Arbeit.

* * * * * * *

"Im Jahre 1815 waren noch 60 Sclaven in dieser Lavra beschäftigt, welche "gegen 2000 Octaven" (19·212 lbs. Troy) "Gold gewannen."

VON ESCHWEGE, *Pluto Brasiliensis*, pp. 295–8.

"Die *Carvoeira* selbst, * * * zeigt rücksichtlich ihrer Gemengtheile "mehrere Verschiedenheiten. Bisweilen nimmt der Braunsteingehalt zu, die "Farbe der Lagermasse wird sodann schwärzlich grau. Schmale Schichten von "Brauneisenstein, der nicht selten schon in gelben Eisenocker aufgelöst ist, "und von Quarz, welcher in abgerundeten Körnern eingewachsen hervortritt, "durchziehen bisweilen die Lagermasse. Kleine Körner gediegenen Goldes, "und sehr kleine nadelformige Krystalle von edlem Schörl setzen in diesem "Gemenge auf. Endlich geht die Lagermasse bisweilen in erdiges, eisenschüs-"siges Graubraunsteinerz über, das aber immer noch mit sehr feinen Quarz-"körnchen gemengt ist. In dieser Bildung enthält es viele Höhlungen, welche "mit silberweissem Talk, theils überzogen, theils ausgefüllt sind. In diesem "erdigen Graubraunsteinerze finden sich Stückchen von graulich weissem "Quarze, mit undeutlichen Krystallen edlen Schörls, eingewachsen. Häufig ist

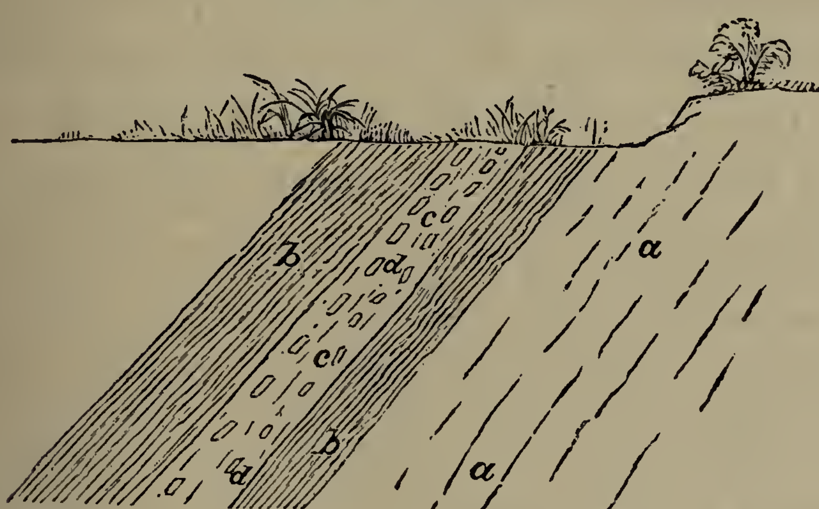
metalliferous quartz-rock beneath,* it always dips towards the east.

Siliceous sand and earthy talc are the chief ingredients; but black manganese and earthy brown iron-ore which also abound,—the former in the lower the latter in the upper portions—impart different hues to the

Fig. 19.

CATTA PRETA. *Carvoeira formation.*

Transverse section.



a Auriferous quartz-rock.
b *Carvoeira* (quartz, talc, manganese, and iron).
c ,, auriferous bed.
d Quartz.

"dieser von dunkel lauchgrüner und schwarzer Farbe, in kleinen und sehr kleinen "haarförmigen Krystallen mit dem sehr feinkörnigen, zerreiblichen Quarze, "welcher einen Theil der Lagermasse ausmacht, so innig verwachsen, dass selbe "als derb erscheint, und dem Schörlfels ähnlich ist. Er bildet einzelne, wie "es scheint, meistens stumpfeckige Stücke, in welchen wieder sogenannter Fett-"quarz mit sehr kleinen Schörlkrystallen eingewachsen ist. Vorzüglich schön "kommt auf diesem Lager der Perglimmer vor. * * * Ein constituirender "Theil dieses goldführenden Lagers scheint der Quarz zu seyn. Er hat eine "rauchgraue Farbe, die durch Eisenoxyd röthlich grau wird. * * * In diesem "Quarze kommt Arsenikkies, wie es scheint, in stumpfeckigen Stücken, von "braunem Eisenoxyd, in welchem gediegen Gold in sehr kleinen Würfeln "eingewachsen ist, umgeben, vor. Er hat eine silberweisse, ins Zinnweisse "übergehende Farbe und keine besondere Merkmale."

VON SPIX und VON MARTIUS, *Reise in Brasilien*, I. pp. 353-4.

* *Ante*, p. 181.

strata, as one or the other prevails. The deeper parts of the deposit enclose isolated crystals, short thin beds, and large lenticular masses (*horses**) of micaceous and oxydulated iron; as well as small irregular layers and reniform aggregations of earthy manganesic ore, containing drusy cavities lined with crystals of manganese. Minute single crystals of dark green schorl are also numerous.

Although the formation formerly yielded much gold near the surface, the only bed which now affords more than a trace bears 10–20° E. of N. and W. of S. to a depth of fifteen fathoms, averages twelve feet in width,† and consists of earthy manganese, brown iron-ore, and siliceous sand,‡ here and there mixed with talc and felspar-clay. Irregularly-shaped, but somewhat rhomboidal, blocks of milk-white quartz (*Fig.* 19, *d*) are, at unequal intervals, imbedded in the other ingredients (*c*), on lines coincident with the strata, both in direction and in dip. These masses of quartz are larger in some

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* Pryce, *Mineralogia Cornubiensis*, p. 99.

† Henwood, *Reports of the Imperial Brazilian Mining Association*, XXXIX. (1845) p. 12.

‡ " The large lode that runs the long way of the estate is * * * composed of " iron and manganese, gold is mixed all through it. The water was drained " with chain pumps, and the ore was drawn up by a water-wheel in small wheel " carriages."—Tregoning, *Ibid*, II. (1826) p. 66.

An average sample afforded,—

" Peroxide of manganese	51·0
" Peroxide of iron	12·6
" Silex	32·0
" Water	4·4
	" 100·0."

Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., &c., MSS.

lines than in others; each series of them has, however, within certain limits, its own peculiar width;* but neither adaptation of confronting faces, nor the other conditions of adjacent blocks, afford evidence of their previous union.† Nests of granular quartz, tinged at times with brown iron-ore, occur, at irregular intervals, in some parts of the mass; whilst small crystals, short threads, and thin plates of gold are scattered through the formation; more sparingly, however, in the quartz than through portions of the adjoining matrix, but thinly even in these.

From fifteen fathoms downward both quartz and gold diminish so rapidly that at eighteen fathoms mere traces of them remain;‡ meanwhile other changes assimilate deeper parts of the auriferous bed to neighbouring barren strata.

The upper, and more ferruginous, beds have been frequently, largely, and closely examined; but in vain.§

The slopes and subordinate ranges of the Caraça are clothed with magnificent virgin forests inhabited by herds of deer, troops of monkeys, and by smaller numbers of the sloth, the *onça*, and other wild

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* Henwood, *Cornwall Geol. Trans.*, v. p. 241.

† Henwood, *Ibid*, III. p. 329; Rule, *Ibid*, VII. p. 161.

‡ "At the eighteen fathom level we have reached the spot at which we should "have intersected the auriferous formation, if it had maintained the direction "and dip observed at the ten. To our disappointment, however, only a trace of "it was found. At the same time siliceous sand, which had already obstructed "us in other parts of the mine, effectually prevented further progress."

Reports of the Imperial Brazilian Mining Association, XLI. (1846) p. 9.

§ *Ibid*, p. 10.

animals. The jacú *(Penelope Marail*)*, the capoeira *(Tinamus Brasiliensis†)*, the nhambú *(Pezus niamba‡)*, the toucan, and many varieties of the parrot tribe, breed in their deepest recesses. The tapir, the capivára *(Hydrochœrus capybara)*, and the otter frequent the tarns, swamps, and streams of every glen in this well-watered region; whilst the rattle-snake, the jararáca *(Bothrops Neuwiedii§)*, and the cainána ‖ abound on the *Canga.*

(*o.*) At the *Corrego de Saõ Miguel,*¶ near Saõ Joaõ do Morro Grande, laminæ of bluish-grey talc and thin irregular strata of compact brown and lamelliform oxydulated iron-ore interlie a bed of micaceous iron nearly sixty feet in width; which presents many irregularities in both direction and dip, but, on the whole, ranges from south-east to north-west, and inclines about 40° towards the north-east.

The ore, when broken with bars of iron *(Alabancas)* and pointed hoes *(almocáfres)*, is washed, for sake of the minute proportion of gold ** mixed with it, and then smelted.††.

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* von Spix und von Martius, *Reise in Brasilien*, I. p. 368.

† *Ibid*, I. p. 325. de Saint-Hilaire, *Voyage dans l'Intérieur du Brésil*, I. p. 282.

‡ von Spix und von Martius, *Reise in Brasilien*, II. p. 464.

§ *Ibid*, I. p. 305.

‖ de Saint-Hilaire, *Voyage dans l'Intérieur du Brésil*, I. p. 408.

¶ " A few very small diamonds of inferior quality have been lately found in the " neighbouring stream.—John Blamey, Esq., MSS.

** The average quantity of gold obtained was 190·17 grains or 0·396 oz. (Troy) per day.

†† The proprietor,—a Priest, of good family,—stores *stamp-heads* in his hall and bar-iron in his sitting-room; and superintends his work-people attired only in a long shirt of printed cotton, wood-soled slippers *(tamancos)*, and a straw-hat.

The iron-formation is overlaid by a laminated mixture of sand and clay; of which certain portions, containing but little iron-ore, have a yellowish-buff; others, more or less ferruginous, are of brown or reddish hue; short thin layers of black manganese-ore are not uncommon; and irregular beds, as well as isolated nests, of felspar-clay occur at intervals throughout the mass; which is of great, though of unknown, thickness.

(*p.*) Near the eastern extremity of the rich metalliferous range,—which, from the neighbourhood of Santa Barbara on the east, beyond Cäethé towards the west, has, at intervals, yielded gold in different rocks,*—the ancient mine of *Cocäes*,† about seven miles

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* *Ante*, pp. 178, 182, 183. *Postea*, p. 24*.

† The mine of Cocaes, "though still rich in gold, is worked by only two hun-"dred negroes. One part of the estate is an auriferous mountain of schistus, "containing beds of micaceous iron-ore; the latter substance forms a thin stra-"tum, which contains gold in grains laminated with it. * * * The discovery of "the original gold mine is said to have been owing to the following accident. "Some negroes in cleaning the land, broke up an ant-hill of considerable size, "when, on laying it open to the air, for the purpose of destroying or dispersing "the insects, large grains of gold were found."

MAWE, *Travels in Brazil*, p. 291.

Cocaës "ist vorzüglich berühmt wegen der Menge und Reinheit des hier "gewonnenen Goldes, das nicht blos fein zertheilt in Quarzgängen eingesprengt "oder im Letten vorkommt, sondern auch in grösseren Stücken, Lamellen und "Krystallen. * * * Der Gehalt des Goldes ist hier so wie in *Morro Grande* "meistens von zwei und zwanzig und einem halben Karat. * * * In demselben "Bezerke werden grosse Bänke von Geschieben eines dichten Brauneisensteins "*(Marumbé)*, Lager von Topfstein, aus welchem man Gefässe geschnitten hat, "und in dem sogenannten Eisenglimmerschiefer häufig Gold gefunden. Unweit "von *Cocaës* auf der Strasse nach dem Diamantendistricte, geht ein feinkörniger "röthlichweisser Granit, welcher bald wieder von quarzreichem Glimmerschiefer "bedeckt wird, zu Tage aus."

VON SPIX und VON MARTIUS, *Reise in Brasilien*, II. pp. 423–4.

"Cocaes * * * doit son existence à quelques minières qui sont donné beau-"coup d'or, mais qui aujourd'hui n'en fournissent plus avec autant d'abondance.

north-east of Saõ Joaõ do Morro Grande, has been extensively wrought in the iron formation. Thin layers, alternately of quartz and micaceous iron, make up the lower part; but a broad band of the latter ingredient, mixed here and there with small quantities of brown manganese, and interlaid by thin irregular beds of yellowish talc, is,—towards its upper boundary,—the chief member of the series.

" Ces mines apartiennent à une seule famille, de laquelle dépendent à peu près " tout le village et le pays environnant. Les chefs de cette famille viennent " d'établir (écrit en 1817), des forges sur le bord du ruisseau d'Una; ils vendent " un partie du fer qu'ils fondent dans leur établissement, et, avec le reste, ils " fabriquent les instrumens nécessaires pour l'exploitation de leurs mines. On " dit que le fer de Cocaes est d'une très bonne qualité; ainsi, lorsque l'or sera " entièrement épuissé dans les alentours, les forges nouvellement établies pour- " ront sans doute encore contribuer à faire subsister, le village."

de Saint-Hilaire, *Voyage dans le district des diamans et sur le Littoral du Brésil*, I. pp. 115–116.

" Das Gebirge " (de Cocaës) " erhebt sich auf der S. O. Seite ganz sanft bis zu " seinem höchsten Rücken etwas über 3000 Fuss, nordwestlich fällt es aber pral- " licht ungefähr 1000 Fuss nach dem Arrayal de Cocaes hinab, und zeigt auf dieser " Seite einen vollkommenen Vertical-Durchschnitt aller auf einander geschichte- " ten Gebirgslagen. Die oberste Schicht, welche an manchen Stellen bis auf den " Rücken des Gebirges hinanreicht, besteht aus einer eisenschüssigen leimigten " Dammerde von mehreren Lachtern Mächtigkeit; unter diesen folgt das Eisen- " stein Conglomerat, welches goldhaltig ist, allein nicht benutzt wird, darunter " folgt der hier so sehr goldreiche Eisenglimmerschiefer mit seinen abwechseln- " den goldhaltigen dünnen Quarzsandlagern. Dieser ruht auf einer mehrere " Lachtern mächtigen Schicht Talkschiefer, der alsdann den Itacolumit-Quarz " zur Unterlage hat, der hier von unbedeutender Mächtigkeit ist, indem man, ehe " man noch den Fuss des Berges erreicht, schon auf Gneiss stösst, auf welchem " isolirte Lager von Hornblendegestein hervortreten. Mitten in den Schichten " des Eisenglimmerschiefers entdeckt man an einigen Orten des Gebirges parallel " mit denselben ungefähr 4—6 Fuss mächtiges Lager jaspis-und eisenkieselarti- " gen Brauneisenstein der hier und da innig mit gemeinem und crystallisirten " Schörl erscheint, eben so wie in einigen Lavras der Serra do Ouro Preto, und " besonders wie an der Serra de Antonio Pereira, indem derselbe ebenfalls gold- " haltig ist, wegen seiner Festigkeit aber wenig benutzt wird.

" Beide * * * grosse lavras treiben ihre Arbeiten nur oben auf dem Rücken " des Gebirgs, und sind nur ungefähr 80 Palmen " (9·6 fathoms) " tief in " dasselbe eingedrungen,"—von Eschwege, *Pluto Brasiliensis*, p. 302.

The basset-edges of these layers, as well as those of the quartzose talc-slates on which they rest, form the steeply-scarped northern side of the mountain.

The approximately parallel beds of *(Itabirite* and *jacotinga)* quartz and of iron-ore are overlaid by a thick crust of *Canga*,* which—conforming to their every flexure—thus gives the surface of the southern slope the contour of the rocks beneath.

In some places the strata bear 30° N, of E. and S, of W., in others, 5° S. of E. and N. of W.; their general range, however, is 10°–20° N. of E. and S. of W., and their dip 30°–55° S.

(1.) Although the thick bed of *(jacotinga)* iron-glance contains very little siliceous matter, the *(Itabirite)* formation immediately beneath abounds in quartz, largely, but irregularly, mixed with calcareous-spar, flecked with micaceous iron-ore, and thinly, yet unequally, sprinkled with gold.†

(2.) At *Alto da Cruz*, a western part of the mine, which has been wrought as deep as twenty-five fathoms, the auriferous deposit is twelve fathoms wide. The subordinate beds maintain, on the whole, a tolerable uniformity in dip and direction; but portions of them present contortions (*Fig.* 20) of which mere verbal description scarcely gives an idea.

The chief constituent is micaceous iron; ‡ but some

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* *Ante*, p. 217. d'Osery, *Compte Rendu*, IX. (1844) p. 675.

† Henwood, *Proceedings of the Cornwall Geol. Soc.*, 1849.

‡ "The mine is situated near the top of the Serra of Cocaes. In the year "1833 a lease for fifty years was bought by the present" (English) "Company;

few thin strata contain earthy brown iron-ore, and others afford traces of manganese. Talc—an ingredient in many, especially in the manganesic, parts of the bed—frequently forms entire layers; of which some are many feet in length, but none are more than a few inches in thickness. Drusy cavities and open joints in the iron-ore are, as at *Agoa Quente*,* sometimes encrusted with stalactitic hydrous oxide of iron; as

Fig. 20.

COCAËS.—ALTO DA CRUZ. *Longitudinal section.*

Contorted strata.

Scale one fathom to the inch.

"the former proprietors had worked it previously for a long period, with much "profit; in June 1834 the company began operations, and though these have "been carried on with much perseverance, and at a great yearly expenditure, "but very little gold has been extracted. At the time of my visit" (1840) "the money laid out on the mine, altogether exceeded £200,000. * * * The "gold is found in a soft friable greyish coloured micaceous iron schist, which is "called by the Brazilians *Jacotinga;* the principal shaft is about fifty fathoms "deep. At the time of my visit, there were thirty English miners, about three "hundred slaves, and thirty hired free Brazilians in and about the mine.

"Between the Serra and the village" of Cocaes "runs the Una, a small stream, "which, however, in the dry season contains but little water. Everywhere along "its banks, and even to a considerable distance, the ground has been turned over "and washed for gold; these operations are still carried on."

Gardner, *Travels in Brazil*, pp. 488-490.

* *Ante*, p. 225.

frequently, however, they contain brilliant interlacing plates of specular iron-ore. Minute particles of gold are irregularly scattered through both manganese and talc; but so thinly, that they are not worth extraction.

The auriferous bed is succeeded by micaceous and earthy brown iron-ore mixed with quartz; and these are overlaid by *Canga.*

Cocäes afforded—

			Oitavas.	lbs. (*Troy*)
in.. 1814	when wrought	by a native Brazilian proprietary	4375·5 *	42·031 of gold;
from 1833 to.. 1846	"	by the National Brazilian Mining Association (an English Company) about		557·000 "

which realized twenty-one thousand seven hundred and eleven Pounds.†

(*q*) Although the same series of rocks forms the southern slope of this chain, throughout its range from east to west, *jacotinga* occurs only at intervals.

Near the Venda do Morro, some six miles west of Saõ Joaõ do Morro Grande, a bed of specular iron-ore, about two fathoms wide, in the glen of Dois Irmaõs,‡ is quarried for the furnace.§

(*r*) It has already been shown that the barren granite near Caëthé|| is, on the south, overlaid by talc-slate at *Rossa Grande* ¶ and this by talcose clay-slate at the mines of *Soares* ** and *Camara*; †† as well as that

* von Eschwege, *Pluto Brasiliensis; Tabellarische Uebersicht aller Goldlavras jeden Districts in der Provinz Minas Geraes*, p. 5.

† *Reports of the National Brazilian Mining Association* 1847, p. 25.

‡ Captain Thomas Blamey, MSS.

§ *Ante*, p. 219. || *Ante*, pp. 174, 178. ¶ *Ante*, p. 178. ** *Ante*, p. 182.

†† 609 tons of quartz, selected from the *Camara* formation, yielded 1 lb. 2 oz. 16 dwts. *Troy* (0·000000744 its weight) of gold.—Captain William Treloar, *Reports of the Imperial Brazilian Mining Association* (20th Dec., 1855) p. 2.

both these rocks are interlaid by subordinate bands of auriferous quartz.*

At *Gongo Soco*, six miles south-east of Caëthé, a few thin schistose beds,—composed for the most part of palish-brown talc, mixed, however, with quartz in minute but unequal proportions,—separate the talcose clay-slates from the great iron-formation; which—coinciding in position with the rocks beneath,† and in contour with the surface,—forms, for many miles, the whole southern slope of the range.

Its outcrop, however, is concealed by sub-angular blocks of specular and oxydulated iron, with an occasional bit of quartz, imbedded in earthy brown,—mottled, at intervals, with earthy red,—iron-ore *(Canga)*.

(1.) Beds, alternately of quartz and of iron-ore *(Itabirite)*,—often less than an inch but sometimes several inches thick, and which, within short distances, maintain tolerably uniform dimensions,—make up the greater part of this deposit. The quartz is often separated from the iron-ore by flakes of talc. Ores of divers qualities, however, not only occur in distant parts of the series; but massive iron-glance, as well as micaceous, oxydulated, earthy black, and pale brown iron-ores, are all ingredients of the self-same layer in various parts of its range.

This portion of the formation—never, perhaps, ab-

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* *Ante*, pp. 182-3.

† von Eschwege, *Annales des Mines*, VIII. (1823) p. 418. Claussen, *Bulletins de l'Académie Royale des Sciences de Bruxelles*, VIII. 1re partie (1841), p. 326.

solutely barren—has nowhere afforded even 0·0000005 its weight of gold.

(2.) The uppermost of these thin strata are interlaid by a bed, from four to seven feet in thickness; which—at intervals charged with, and sometimes enclosing crystalline masses of, calcareous matter*—is composed, for the most part, of quartz,† flecked with micaceous iron-ore and with talc.* Like that at *Cocäes*,‡—of which it may, perhaps, be either a continuation or an equivalent,—it is never quite destitute of gold, either at the surface or in the mine; yet the richest portions wrought yielded only 0·0000000021 their weight of it.§

(3.) A mere scale of *(Itabirite)* rock, identical in composition with that beneath the calcareo-siliceous deposit, divides it from the next number of the series; which—mixed, at intervals, with other, and sometimes more valuable, ingredients—consists, for the most part, of iron-ore.

(3—1.) The bedding—everywhere parallel to the cleavage—bears 3°—11° N. of E. & S. of W.; and dips 30°—50° towards the south.

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* A broad band of quartz, calc-spar, micaceous iron-ore, and talc, laid open, at the surface, as well as at the 27 and 48 fm. *levels*, afforded, at the *Stamps*, a few particles and grains of gold, but by no means enough to repay the cost of extraction.—Henwood, *Reports of the Imperial Brazilian Mining Association*, xxxix. (1845) p. 10; xli. (1846) p. 8.

† Trebilcock, Bennetts, Prideaux, Hambly, Harris, Bray, Collins, Blamey, and Pengilly, *Ibid.* vii. (1829) p. 97; viii. pp. 82–86; xii. (1831) p. 74; xix. (1835) p. 47; xxi. (1836) p. 87; xxviii. (1839) p. 41.

‡ *Ante*, p. 245.

§ 216 tons of the quartz formation yielded, at the *Stamps*, 3 dwts. of gold.—Guy, *Reports of the Imperial Brazilian Mining Association*, lii. (1851) p. 10.

The joints, which bear
nearly........ N. & S.;—
about 30°—40° S. of E. & N. of W.;—
and 3°—15° N. of E. & S. of W.,

respectively, are best defined in the quartzose iron-slate *(Itabirite)*; where a *cross-* (drift) *cut*, more than eighty fathoms long, was amply ventilated by currents of fresh air—whencesoever derived—emitted by these natural crevices in the rock.*

The iron-formation consists of two nearly parallel beds; which—differing rather in the disposition and proportions than in the nature of their ingredients—are more easily identified than described. In some parts of their range they are separated by quartzose iron-slate,† scarcely distinguishable from the *Itabirite* (1—3) below: in others, however, this is either so thoroughly transfused with certain elements of the adjoining rocks as to be scarcely recognised, or is altogether wanting; and in such cases neighbouring portions of the different beds are much alike.

(3—2.) As the northern or *Gongo* deposit has been

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* Henwood, *Cornwall Geol. Trans.*, III. p. 204.

Not far from the bottom of a well, sunk 17·6 fathoms, at Belvedere near Erith, by Sir Culling Eardley Eardley, Bart., several crevices in the chalk—probed to an extent of seventy or eighty feet—emitted rapid currents of air; charged, at first, with calcareous dust, but mixed, afterwards, with fresh water; which—gradually increasing until it amounted to 3,200 feet per day—rose at length to within sixteen feet of the surface; a level it—never once freezing—has, with little variation maintained ever since (1861).

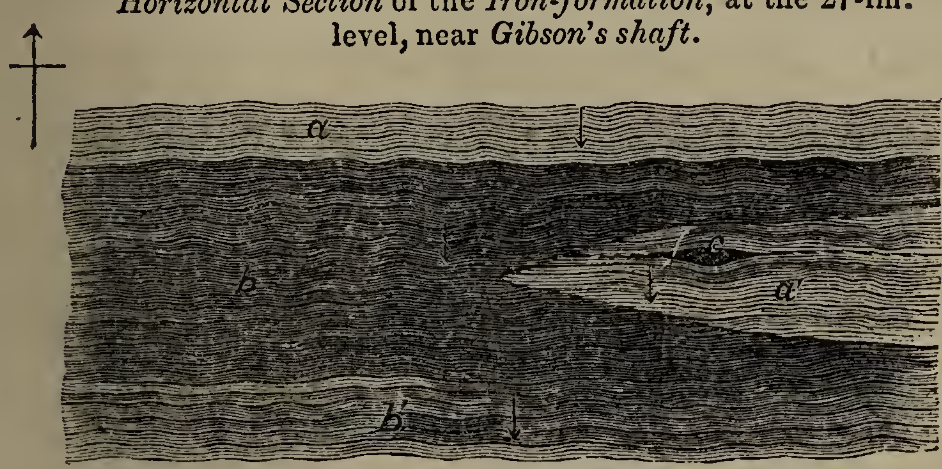
† "The Jacotinga west of Bray's shaft is divided by the *Cumba horse*, a fer-"ruginous *Itacolumite*, into two branches."

von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Reports of the Imperial Brazilian Mining Association*, XXX. (1840) pp. 51, 84.

laid open by scores of shafts and miles of levels, its width, in different parts of the mine, has been fully ascertained. At the 27-fm. *level,* near *Gibson's* shaft *(Table VIII.,* column 21), however, notwithstanding both bounding-planes (*walls*) maintain their normal bearing and dip, it is divided into two bands, of unequal thickness, by a wedge-shaped (*horse*) mass, which—resembling, both in composition and in structure,* the *(Itabirite)* rock (1–3) immediately beneath; —widens as well towards the east as in deeper parts of the mine.† And this is, in like manner, interlaid by at least one thin conformable bed of auriferous *(Jacotinga)* manganesic iron-ore.

Fig. 21. GONGO SOCO.

Horizontal Section of the *Iron-formation*, at the 27-fm. level, near *Gibson's shaft.*



a Quartzose iron-slate *(Itabirite)*. *b Gongo* Iron-formation.
á Horse of ,, ,, . *b' Cumba* ,, .
c Auriferous bed within the *Horse.*

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* Henwood, *Cornwall Geol. Trans.*, v. *Table L.* column 6. *Ante.* p. 191.

† " A hard *dead* stratum or *horse* thrusts itself into the Jacotinga at Gibson's " shaft, and appears to be increasing in size as it goes eastward."—Hocheder, *Reports of the Imperial Brazilian Mining Association,* xxii. (1836) pp. 86–7.

In some places two or three feet,* in others as many inches only,† below, yet nowhere in actual contact with the *North (bed) vein* (a subordinate member of the auriferous series), the *Slide*—three or four inches thick ‡ and five or six fathoms high—slopes *(shoots)* endlong from the 21-fathom level west of *Macfarlane's*—eastward—to the 34 near *Lyon's* shaft. Within this range it is composed of talc and quartz, interspersed with small crystals of oxydulated iron; beyond, however, it has no existence; but is bounded above, below, at either end, and on both sides, by iron-ore.

The southern or *Cumba* bed—exhibiting few of the characters which presage gold in the *Gongo* deposit—has been, for the most part, examined by *cross-cuts* (drifts) from the north; § its dimensions, therefore, are less generally known.

The following columns show the width of the iron-formation, at various parts, and at different depths, in the mine.

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* Hocheder, *Reports of the Imperial Brazilian Mining Association*, XVI. (1833) p. 60.

† *Ibid*, XVII. p. 64.

‡ Williams, *Ibid*, XVII. p. 124.

Table VIII. column 3; Note *f.*

§ von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Reports of the Imperial Brazilian Mining Association*, XXX. pp. 86-7.

Locality.	Depth.	*Gongo* formation. Breadth, fms.		*Cumba* formation. Breadth, fms.	Total. Breadth, fms.
Angove's shaft.	Surface ..	80·0 * ..		75·0 †	155·0 †
Allcock's ,,	21-fm. level ..	— ..		—	51·0 ‡
Stokes's ,,	7-fm. level ..	17·5 §			
	14-fm. ,, ..	17 0 §			
Lyon's ,,	Surface ..	20·0 ‖			
	7-fm. level } 21-fm. ,, }	15·0 ¶			
	27-fm. ,, } 41-fm. ,, }	14·0 ¶			
Gibson's ,,	27-fm. level ..	Divided by a (*horse*) mass of rock; which widens both in depth & towards the east.**			
		North part.	*South part.*		
		0·50	2·8		
	34-fm. level ..	....	2·6 ††		
	41-fm. ,, ..	Isolated masses.‡‡ 0·10	2·0 §§		
	48-fm. ,, ..	0·08 ‖‖			
Bayly's ,,	34-fm. level ..	....	2·0¶¶		
	41-fm. ,, ..	Isolated nests.*** 0·06			
	48-fm. ,, ..	— ..	—	15·0 †††	
	55-fm. ,, ..	— ..	0 6	8·2 ‡‡‡	8·8

* Hocheder, *Reports of the Imperial Brazilian Mining Association*, XV. (1833) p. 54.

† Trebilcock, Hambly, & Prideaux, *Ibid*, VIII. (1829) p. 80. Hocheder, *Ibid* XV. Pl. I. fig. 1; XVII. (1834) p. 83. von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Ibid*, XXX. (1840) p. 84.

‡ Harris, Bray, Collins, Blamey, and Pengilly, *Ibid*, XXIX. (1840) p. 51.

§ Hocheder, *Ibid*, VIII. Pl. I. fig. 2.

‖ Edwards, *Ibid*, I. (1825) p. 20.

¶ Hocheder, *Ibid*, VIII. Pl. I. fig. 3.

** *Table VIII.* column 21.

†† Hocheder, *Reports of Imperial Brazilian Mining Association*, XVII. p. 119.

‡‡ *Ibid*, XVII. p. 101.

§§ *Ibid*, XVI. p. 47.

‖‖ Tregoning, Harris, Bray, and Collins, *Ibid*, XXII. (1836) p. 111.

¶¶ Hocheder, *Ibid*, XVI. p. 47.

*** *Ibid*, XVII. pp. 101–4.

††† Tregoning, *Ibid*, XVIII. (1834) Pl. I. fig, 1.

‡‡‡ Harris, Bray, Collins, Blamey, and Pengilly, *Ibid*, XXVIII. (1839) p. 59.

Locality.	Depth.	*Gongo* formation. Breadth, fms.		*Cumba* formation. Breadth, fms.	Total. Breadth, fms.
		North part.	*South part.*		
Vesey's shaft.	48-fm. level ..	— ..	2·0 *		
	55-fm. " ..	— ..	0·6	7·5 †	8·1
	62-fm. " ..	— ..	0·2 ‡	§	
	70-fm. " *E.*	— ..	0·2 §	§	
	80-fm. " *E.*	— ..	0·05 ‖	‖	

Thus, within a range of six hundred fathoms, the northern or *Gongo* deposit dwindles from about 80 fms. to a few inches; and the southern or *Cumba* " " 75 " to about 7½ fathoms in thickness.

(3—3.) The *Gongo* formation consists, for the most part, of micaceous and massive iron-glance; ¶ more or less mixed, however, with oxydulated iron-ore towards the east.** From *Angove's* shaft to *Pengilly's*, and again, from *Duval's* to *Allcock's (Pl. II. Fig. 2)*, the other ingredients are interlaminated with earthy brown iron-ore; which between *Pengilly's* and *Duval's* is mingled with,—and between *Allcock's* and *Aveline's* shafts is replaced by,—earthy black iron-ore; whilst smaller quantities of both occur elsewhere. Great part of the *Gongo* formation is irregularly sprinkled

* Hocheder, *Reports of the Imperial Brazilian Mining Association*, XVIII. p. 46.

† Harris, Bray, Collins, Blamey, and Pengilly, *Ibid*, XXVIII. p. 59.

‡ von Helmreichen, Harris, Collins, Blamey, and Pengilly, XXX. p. 81.

§ Henwood, *Ibid*, XXXIX. (1845) p. 10.

‖ *Ibid*, XL. p. 11; XLI. (1846) p. 9.

¶ von Eschwege, *Annales des Mines*, VIII. (1823) p. 413. Edwards, *Reports of the Imperial Brazilian Mining Association*, I. (1825) p. 20. Hocheder, *Ibid*, XV. p. 54. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, VIII. 1re partie (1841) p. 327. von Helmreichen, *Gardner's Travels in Brazil*, (1846) p. 494. Henwood, *Edinburgh New Phil. Journal*, L. (1851) p. 61.

** von Eschwege, *Annales des Mines*, VIII. p. 413.

with gold;* which, however, is seldom abundant enough to be worth separation. Ore obtained at a distance of several fathoms from the chief auriferous *(veins)* bands, yielded—when *stamped*—the under-mentioned proportions:—

Date.	Gold. Grains, per ton *(Avoir.)* of ore.	Gold. Proportion.
1837	6·6	0·000000422; †
1850, July—December	12·0	0·000000765; ‡
1851, January—June	6·5 §	0·000000415;
„ September	8·0 §	0·000000510;
	3·0 §	0·000000191.

Laminæ and small irregular beds of buff-coloured talc also conform to the complicated volutions which are numerous in the bands of iron-ore they interlie; and—towards the east especially—face every joint and seam. Quartz is neither a congenial matrix,|| nor even a constant ingredient amongst the richer ores;

* In Lyon's shaft the *Jacotinga* at fourteen fathoms from the *vein* answers for *stamping;* and this is also the case at considerable distances in other parts of the mine.—Harris, Jeffery, Bray, Jennings, & Collins, *Reports of the Imperial Brazilian Mining Association*, xiv. (1832) p. 71.

"Part of the ore *stamped* is brought from the *cross-cuts*; which, although it "yields a little gold, is poor compared with that taken from the *veins*."

Tregoning, Harris, Bray, & Jennings, *Ibid*, xviii. (1834) p. 84.

At the 41-fm. *level*, near *Bayly's* shaft, the *Jacotinga*, three fathoms north of the *vein*, shews a little gold when washed.

Tregoning, Bray, Harris, & Simmons, *Ibid*, xix. p. 51.

† Tregoning, Harris, Bray, and Collins, *Ibid*, xxii. p. 120.

‡ Walker, *Ibid*, l. p. 3.

§ "These trifling contents of gold per ton of *Jacotinga* prove the * * * in-"expediency of incurring the outlay of much, if any, further capital."

Walker, *Ibid*, li. pp. 4, 5.

"The deposition of gold in *Jacotinga* has no relation to the quartz formation "of the country."—Hocheder, *Ibid*, xvii. p. 51.

|| *Ante*, p. 229.

but—generally mingled with talc, and mixed with either iron-glance, oxydulated iron, iron-pyrites, or, more largely and more generally with earthy pale-brown iron-ore,—it is a chief constituent of the barren and contorted beds into which the auriferous strata gradually pass towards the east.

That part of the *Cumba* formation which was, for many years, wrought by the native proprietors as an *open-work (Talho Aberto)** at *Canta Gallo*, immediately west of the mine,† consists, in great measure, of micaceous iron-glance; interlaid, however, by thin beds of granular quartz, tinged with earthy brown iron-ore. Near *Blamey's* and *Collins's* shafts the iron-glance — rarely massive,‡ sometimes granular, but generally micaceous — is often disintegrated, and largely, yet irregularly, mixed, as well with earthy black and brown ore, as with clay. From *Luke's* to

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* *Table VIII.*, column 3.

† The *Jacotinga* which has been worked at *Canto Gallo* by the native proprietors bears about 20° N. of E. & S. of W., dips 35° S., and, in its range towards the east, appears to rest on the *Gongo* formation. In one spot, at which operations have been lately resumed, those "layers which are most associated with "the oxide of iron, contain more gold than others with less oxide, and in those "in which no oxide of iron exists I could detect no gold at all, or only a trace "in the samples." * * * In a second spot, which has for many years been uninterruptedly prosecuted as an *open-work (Talho Aberto)* a few negroes have been employed in "cutting down the whole mountain into the river, and con- "ducting the water with the *stuff* * * * over *Strĕkes* covered with hides. The "gold existing in both these *open-works* is very minutely disseminated through the entire body of the rock; consequently the whole must be quarried and "stamped." The proportion of gold is, however, "so inconsiderable, that it is "my firm conviction this mode of working, or rather the formation so worked, "can never be an object to an English Company."—HOCHEDER, *Reports of the Imperial Brazilian Mining Association*, XVII. pp. 84–6.

von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Ibid*, XXX. pp. 84–6.

‡ Hocheder, *Ibid*, XVII. p. 105.

Crickitt's, and thence eastward to the *cross* (drift) *-cut* south of *Jennings's* shaft, the earthy ores affect separate beds,* but—indistinctly bounded—they mix by degrees with iron-glance at the sides. From the meridian of *Jennings's* shaft eastward the iron-glance is, to some extent, replaced by oxydulated iron, but earthy black and brown iron-ore are still common; quartz, also, either forms small irregular layers,† or is mingled with the clay, which—everywhere abundant—is, at intervals, the chief ingredient. Talc is much more plentiful in this formation than in that below; but, whilst generally disposed in isolated masses and short, thin, conformable beds, it is sometimes the principal constituent. Between *Canta Gallo* and *Collins's* shaft the particles of gold imbedded in the rock enclosing several short, thin, narrow bands,‡ which have afforded, at intervals, a few *bunches* § of rich ore, are larger

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* Harris, Bray, Blamey, and Pengilly, *Reports of Imperial Brazilian Mining Association*, XXVIII. p. 62.

† Tregoning, Harris, Bray, and Collins, *Ibid*, XIX. p. 47; XXI. p. 92.

‡ A cross-cut at the adit in *Cumba* has intersected several veins, but they are all poor.—TREBILCOCK, HAMBLY, & PRIDEAUX, *Ibid*, VIII. p. 80.

" In the *Cumba* formation there are various auriferous veins."

HARRIS, BRAY, BLAMEY, & PENGILLY, *Ibid*, XXVII. p. 60.

We have had in *Cumba* as many as three gold-veins side by side in the same *workings*, which are here no less than nine or ten feet wide; and in addition to the rich ores, which are taken in boxes to the *washing-house*, the ore for a considerable width beyond the veins will give a good produce at the Stamps.

HARRIS, COLLINS, BLAMEY, PENGILLY, & VON HELMREICHEN, *Ibid*, XXX. p. 55.

§ " We have cut a vein in the *Cumba* which has given 4½ oz. of very fine gold, " and still affords *prills*" (solid lumps) " of small size."—LYON, *Ibid*, VII. p. 31.

" We had 4 lbs. from the *Cumba* in one day."—SKERRETT, *Ibid*, X. p. 27.

" At the *Cumba* on one occasion during the past month the vein yielded about " 2 oz. of gold for the *washing-house*."

HARRIS, BRAY, BLAMEY, & PENGILLY, *Ibid*, XXVII. p. 54.

The *Cumba* mine, which has already yielded a considerable quantity of valuable

and more numerous than in other parts of the deposit. Portions of the strata, which enclosed the smallest and poorest of those bands, gave at the *Stamps* 0·000017 their weight * of gold. Near the middle of the mine considerable portions of this formation were laid open by *levels* (galleries) from *Luke's* † and *Crickitt's*,‡ as well as by *cross* (drifts)-*cuts* from several other shafts; § but—though parallel to the richest part of the *Gongo* system ||—it yielded merely small grains of gold, far too widely scattered to repay the cost of extraction. Amongst some thousand samples taken from many eastern parts of the mine, none contained more than a barely discernible particle or two of gold.¶

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ore for the *Stamps* afforded from the 26th to the 30th of October, 1840, upwards of 23 lbs. of gold for the *washing-house.*

von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Reports of the Imperial Brazilian Mining Association*, xxx. p. 85.

* 36 tons of ore reduced in twenty-four hours yielded 1 lb. 8 oz. 19 dwts. 11 grs. of gold.—Duval, *Ibid*, xxii. p. 83.

† Henwood, *Ibid*, xliii. p. 5.

‡ Harris, Bray, Collins, Blamey, Pengilly, von Helmreichen, and Henwood, *Ibid*, xxix. pp. 38, 44, 51, 56; xxx. pp. 48, 52; xxxi. pp. 41, 43; xxxviii. p. 2; xxxix. p. 10; xl. p. 10; xli. p. 8; xliii. p. 5.

§ Hocheder, Harris, Bray, Collins, Blamey, Pengilly, von Helmreichen, and Henwood, *Ibid*, xxiv. p. 45; xxx. pp. 65, 86; xxxi. pp. 24, 27, 41, 43; xl. p. 10; xliii. p. 5.

|| "It is commonly believed that wherever a lode is rich, if there be another "lode near it, having nearly the same direction, and in the same *country* * * * "it is probable that the second lode will be found rich in that part which is op- "posite to the rich part of the first lode. This is not a new doctrine: the phrase "*ore against ore* is probably of earlier date than the present generation of "miners."—Carne, *Cornwall Geol. Trans.*, iii. p. 78.

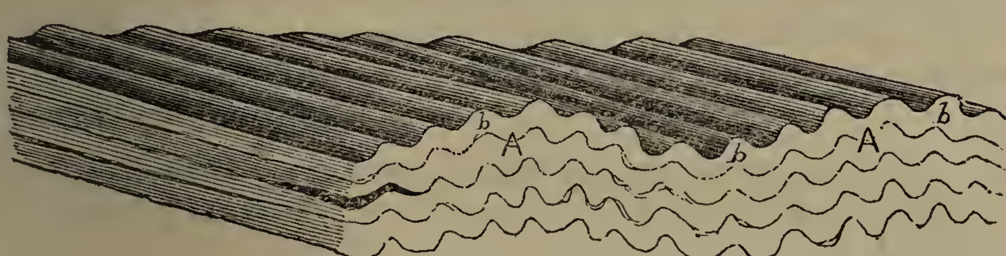
Henwood, *Ibid*, v. pp. 215, 233.

¶ Hocheder, Tregoning, Jennings, Harris, Bray, Collins, Blamey, Pengilly, von Helmreichen, Crickitt, and Henwood, *Ibid*, xvii. pp. 69, 95; xviii. pp. 46, 56, 61, 71, 76; xix. pp. 38, 41, 45, 51, 53; xx. pp. 65, 68; xxi. p. 74; xxiv. p. 45; xxviii. p. 59; xxxiii. p. 1; xli. p. 9.

(3—4.) In great part of both these deposits a schistose structure prevails; which—generally parallel to the bedding and foliation of the rock beneath—bears 3°—11° N. of E. & S. of W., whilst it inclines 35°—60° S. The same lines of cleavage are common to the auriferous portions of the *Gongo* formation, and to the wedge-shaped *(horse)* mass of iron-ore and quartz, which interlies them towards the east.*

Near the richer *(shoots—bunches)* masses of ore certain strata exhibit broad undulations *(Fig.* 22, A A),† which are frequently furrowed with narrower waves.‡ These flexures, whether large or small, have, amongst themselves, an approximate parallelism; which in some measure conforms to the slope of the goldless granite § near Caëthé on the north-west; whilst—oblique to the normal direction and inclination of the beds — they dip 8°— 30° towards the east.

Fig. 22. GONGO SOCO.
Flexures of the iron strata.



* *Ante*, p. 251, *Fig.* 21.

† "The curves are sometimes simple, like the superficies of a cylinder."
BOASE, *Primary Geology*, p. 114.

‡ "In some cases the irregular surface of the beds is apparently due to original "*ripple-structure*, which by the general movement of the mass of the rock across "the cleavage-planes, have acquired superposed wrinkles."
PROF. PHILLIPS, *Reports of the British Association* (1856), p. 388.

§ Henwood, *Cornwall Geol. Trans.*, v. p. 193; vi. p. 146; *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, xxv. (1844) p. 353. *Ante*, pp. 207, 234.

Subordinate portions, as well of the *Gongo* as of the *Cumba* series, however, exhibit intricate volutions, which neither affect adjoining strata nor reach even the confines of the containing bed.*

At wide and irregular intervals, however, portions of the crystalline iron-glance assume a massive structure.†

(3—5.) Small quantities of rich iron-ore broken near *Pengilly's* shaft,‡ on the *Gongo* formation, were smelted § at Taboleiro near the mine; but as the native

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* In micaceous schist "the lesser undulations and curvatures, are, evidently, "often independent of any corresponding change in the evenness of the bed; "and the same probably often holds true of the more complicated, since they do "not seem to pervade the whole mass, but rather to occupy particular spots "among the neighbouring and less disturbed laminæ."

Macculloch, *System of Geology*, II. p. 160.

Boase, *Primary Geology*, p. 114. Sorby, *Edinburgh New Phil. Journal*, LV. (1853) p. 138.

† As we have extended the 21-fm. level west of *Walker's* shaft the ground has considerably altered, and now consists of hard iron stone.—Hocheder, *Reports of the Imperial Brazilian Mining Association*, XVII. pp. 59, 68.

"A *cross-cut* north of *Lyon's* shaft at the 48-fm. level has traversed a hard, "massive rock, composed wholly of specular iron-ore."

Henwood, *Ibid*, XXXVIII. p. 3.

"In the *cross-cut driven* towards *Bayley's* shaft at the 55-fm. level we have an "exceedingly hard iron rock."—Harris, Bray, Blamey, & Pengilly, *Ibid*, XXVII. pp. 51, 56.

The *cross-cut* north of *Vesey's* shaft at the 48-fm. level still penetrates a very hard iron rock.

Tregoning, Harris, Bray, & Collins, *Ibid*, XXII. pp. 98, 102.

In the *Cumba adit cross-cut* the rock was alternately hard iron stone, and talc schistus intermingled with micaceous iron-ore.—Hocheder, *Ibid*, XVII. p. 83.

‡ Captain Blamey, MSS.

§ The ores of Gongo Soco are rich and good, but they require a very different mode of treatment to the one adopted in this country with the argillaceous iron-ore; one very nearly, if not, indeed, the same, with that used in Sweden. I see

manufacturers * sold their iron more cheaply than it

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no reasonable doubt that, by such a process, they would give good pig-iron.

Raw ore selected for analysis yielded per cent.—

	First experiment.	Second experiment.
Peroxide of iron	97·00	95·20
Silica	1·60	2·57
Alumina	1·10	2·79
Oxide of manganese	0·60	0·71
Lime	a trace	a trace
	100·30	101·27

The excess in analysis is occasioned by a small portion of the iron in the ore being in a minor degree of oxidation.

The limestone, sent from the same place, contained very variable quantities of the accompanying rock; which introduced silica, alumina, and magnesia into the furnace.

The only sample of slag from a Brazilian iron-furnace, which I have seen, was of the worst possible quality; for it contained such an enormous quantity of oxide of iron, as to make it equivalent to a rich ore. By analysis it gave per cent.;—

Metallic iron	2·82
Protoxide of iron	46·80
Silica	28·00
Alumina	5·20
Oxide of manganese	0 30
Lime	11·20
Magnesia	5·40
	99·72

Faraday, *Reports of the Brazilian Mining Association*, v. (1828) pp. 89–95.

† The natives of Minas Geraës select for smelting that iron-ore which is free from alumina, and other impurities; break it into pieces the size of a pigeon's egg, but do not calcine it. Lime is sometimes used in the fusion. Their furnaces are about three feet high and ten or twelve inches in diameter, and suitable pits are prepared beneath them for receiving the fused metal. The iron, having been once fused, is immediately laid on an anvil and hammered out to the required dimensions.

A superintendent *(feitor)* and sixteen labourers select the ore and prepare the charcoal for three or four (and occasionally even for six) such furnaces; which —usually charged fifteen times and worked by a second overseer and five other persons—yield on an average two hundred and seventy lbs. of good maleable iron.

	£	s.	d.
The attendant expenses are wages and food of 23 people, say one shilling and three pence per day each	£1	8	9
of two cars for conveyance of ore, charcoal, &c.	0	10	0
of one car ,, iron to market	0	5	0
	£2	3	9

or rather less than eighteen shillings and two pence per (112 lbs.) cwt.

Baird, *Ibid*, vii. p. 82.

was prepared on the spot,* operations were soon discontinued.

(3—6.) The most important part, however,—sometimes made up of several layers each scarcely thicker than paper, sometimes forming a single bed varying from a fraction of an inch to three or four, but seldom as much as six, inches in width, yet conforming to every flexure of the rocks adjoining—occurs near the middle of the series.†

Of the narrower portions earthy brown iron and manganese are chief ingredients; but west of *Pengilly's* shaft at the *tram* and *shallow*,—of *Williams's* at the *shallow* and seven fathom *level*,—of *Allcock's* at the seven and fourteen fathom *levels*,—and in other western parts of the mine, these ores are often mixed with iron-glance; eastward, however, small crystals of oxydulated iron are numerous, whilst iron-glance is, perhaps,

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* "We must not make iron so long as we can purchase it."—Skerrett, *Reports of the Imperial Brazilian Mining Association*, xii. p. 33.

The natives who manufacture iron in our neighbourhood are supplied with charcoal by their slaves at one-half the price it costs us; they are therefore able to make iron cheaper than we can. The Brazilians are accustomed to prepare their charcoal in *pits;* ours, however, is made in *heaps*. Manufactured in either way it is equally useful for furnaces; but heap-burnt charcoal is the most serviceable for forges. Mr. Rooke, our chief forester, calculates that (an *alquiere*) 2,772 cubic inches of charcoal made in heaps, under his superintendence, costs (one hundred and fifty *reis*) about four pence, three farthings.

von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Ibid*, xxx. p. 88.

† About the middle of the disintegrated iron-mica schistus manganese—largely mixed with one or more layers parallel with the general strata—renders this part, known by its brownish-black colour and greater softness, more or less distinct from the rest of the formation. These distinct layers of jacotinga form the *lode*, in which the great riches of Gongo Soco are deposited.

Hocheder, *Ibid*, xv. p. 54.

rather less abundant. In both cases it is difficult, if not impossible, to distinguish the auriferous band from other strata.

The broader parts—connected by narrower layers—are grouped in two *(shoots)* masses of irregular form and unequal dimensions (*Pl. II. Fig.* 2).

(—*a.*) The smaller *(shoot)* mass crops out at the surface west of *Pengilly's* shaft; and, dipping 8°—30° towards the east,—as the striæ or undulations in the iron-mica-slate also dip *—is wrought to the 21-fathom *level* beyond *Duval's;* † a range of more than two hundred and twenty fathoms. Its width seldom exceeds three inches, and is generally less than an inch. The chief ingredient is iron-glance; of granular structure and mixed with earthy brown iron-ore in some places,—but foliated and invested with earthy black iron-ore in others where it encloses irregular lumps of earthy hydrous oxide of iron and earthy brown manganese. Buff-coloured talc is common; but friable quartz is peculiar to the granular, and pearl-white talc to the foliated, iron-ore. Within short

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* Henwood, *Cornwall Geol. Trans.* v. p. 193; vi. p. 146: *London, Edinburgh, and Dublin Phil. Mag.*, 3rd series, xxv. (1844) p. 343. *Ante*, pp. 207, 234, 259, *Fig.* 22.

† By following up the Gongo main vein, through a poor piece of ground 90 fathoms in horizontal extent, a new *shoot* was discovered near Duval's shaft. * * * This has, as far as we know at present, only reached down to the 21-fathom level east of Duval's, and it becomes very poor even there. West of that shaft it commenced to rise above the 14-fathom level, and continued rising in a westerly direction. * * * The extent of this *shoot* measured at right angles to its line of dip is from 12 to 18 fathoms.

von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Reports of the Imperial Brazilian Mining Association*, xxx. (1840) p. 83.

distances, however, differences, of structure and composition, are frequent.

A vein, unseen on the south, springs from the northern *(wall)* side of the auriferous *(Jacotinga)* deposit; and—parallel to one series of joints* in the iron-formation—bears 2°—5° S. of E. & N. of W. It is usually less than an inch, but never more than two inches, wide. Iron-glance, buff-coloured talc, earthy brown iron-ore, and manganese are its ordinary constituents, but here and there these are mixed with other substances.†

(—*b.*) The larger (*shoot*) mass appears at the surface on the same meridian at which the smaller—separated from it by a body of inferior ore—dies out in the 21-fathom level east of *Duval's;*‡ and—accommodating itself (so to speak) to the ridges, furrows, and flexures, which, in the (*walls*) rocks on both sides,§ dip 10°—28° east ‖—extends to the sixty-two near *Vesey's* shaft,¶ a distance of more than two hundred and fifty fathoms. Its thickness is sometimes no greater than that of gold-leaf, but never exceeds six inches. In this, as well as in the smaller, *shoot* the principal constituent is iron-glance; of which the granular variety—mixed now and then with earthy

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* *Ante,* p. 250.

† von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Reports of the Imperial Brazilian Mining Association,* XXVI. p. 49; XXX. p. 83.

‡ *Ante,* p. 250. § *Ante,* p. 259, *Fig.* 22.

‖ Hocheder, *Reports of the Imperial Brazilian Mining Association,* XV. p. 55. von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Ibid,* XXX. p. 81.

¶ *Pl. IV, Fig.* 2.

brown, but more frequently with earthy black, iron-ore,—is generally disposed towards the (*walls*) sides; whilst the lamellar kinds*—interlaminated with buff-coloured talc,—enveloping sometimes isolated lumps, sometimes subordinate layers, of earthy manganese, irregularly mingled with earthy hydrous oxide of iron, often sprinkled with pearl-white talc, and yet more sparingly with smaller quantities of other ingredients* —usually form the middle of ordinary portions, but alternate with granular ore in wider parts, of the deposit. Near the laminated mass (*horse*) of quartz and iron-ore which splits the *Gongo* iron-formation, east of *Gibson's* shaft,† every buff-coloured talcose member of the auriferous (*Jacotinga*) bed is thickly studded with small crystals of oxydulated iron. Still further towards the east, however, these substances form detached masses, progressively smaller and further apart; at first imbedded in, but at length replaced by, beds alternately of pale-brown earthy iron-ore and quartz.‡

(3—7.) Several thin unconnected bands of (*Jacotinga*) iron-glance, manganese, and talc interlie the schistose iron-ore within short distances on either side

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* The chief ingredients of the *Jacotinga* are iron-mica and quartz, which enclose beds of manganese from a quarter of an inch to three inches in thickness, as well as strings and nests of iron-glance and talc. The manganese beds have like the adjoining rocks, a southerly inclination, as well as a general *(shoot)* dip towards the east.

HOCHEDER, *Reports of the Imperial Brazilian Mining Association*, XV. pp. 54—55.

† *Ante*, p. 251; *Table VII.* column 21.

‡ von Helmreichen, Harris, Collins, Blamey, and Pengilly, *Reports of the Imperial Brazilian Mining Association*, xxx. p. 81.

of the *principal* (*vein*) *bed* between *Walker's* and *Bayly's* shafts; * but they seldom exceed a few feet in length and depth.

(3—8.) The *North* (*vein*) *bed* forms part of the *Gongo* iron-series, and—partaking its flexures—ranges from three feet to ten fathoms beneath the *principal* † (*vein*) *bed*; but—never cropping out at the surface—has no existence, either above the fourteen or below the forty-one fathom level,—either west of *Walker's* shaft or east of *Bayly's*. It extends,—

								fms.
At the	14-fm. level	from *Walker's*	shaft W.	to	*Lyon's*	E. ..	about	72;
,,	21-fm.	,, *Macfarlane's*	,,	....	*Lyon's* ‡	,, ..	,,	34;
,,	27-fm.	,, *Macfarlane's*	,,	....	*Lyon's*	,, ..	,,	34;
,,	34-fm.	,, *Lyon's*	,,	....	*Gibson's*	,, ..	,,	28;
,,	41-fm.	,, *Curtis's*	,,	beyond	*Gibson's*	,, ..	,,	21;

thus forming an irregular oval, about one hundred fathoms in length and fourteen in extreme depth, which dips endlong, 8°—14° towards the east. Its thickness—never exceeding two inches, and generally less than an inch — gradually diminishes upward, downward, and at either end; until, at length, it disappears between the rocks which elsewhere form its opposite (*walls*) sides. Within short distances of the *Slide* § crystals of oxydulated iron are imbedded in a

* Several small veins (beds) of manganese and talc are included in the rock between the two principal bands of jacotinga.

VON HELMREICHEN, HARRIS, COLLINS, BLAMEY, & PENGILLY, *Reports of the Imperial Brazilian Mining Association*, XXX. p. 82.

† "The North vein in the twenty-one fathom level is about ten fathoms, three "feet, six inches, north of our principal vein; but in the fourteen fathom level, "where it discontinues its course upward, it is no more than about three feet "six inches distant."

JENNINGS, COLLINS, HARRIS, BRAY, & JEFFERY, *Ibid*, XIV. p. 66.

‡ Duval, *Ibid*, XXI. p. 65.

§ *Ante*, p. 252; *Table VIII.* columns 3, 15.

talcose matrix; whilst elsewhere wider parts of this band contain larger quantities of the earthy hydrous oxide of iron than those of the *principal (vein) bed;* in other respects the mineral characters of their parallel sections are much alike.

(3–9.) The *New North (vein) bed*, a lower member of the *Gongo* iron series, is wrought—mostly some fifteen fathoms, but in some places scarcely as many feet, beyond the *North (vein) bed*—from the surface north of *Walker's* to the thirty-four fathom *level* near *Aveline's* shaft. It neither holds down to the seven fathom *level* at one end nor reaches the surface at the other; but—forming an irregular oblong about one hundred fathoms long by twelve deep—dips 17°—20° towards the east. Generally less, but never more, than an inch in width, it gradually declines, as well towards either end, as towards the bottom of the mine; until, near *Walker's* shaft on the west, at *Aveline's* in the east, and at the thirty-four fathom *level*, it—like the *North (vein) bed**—at last dies away. The ingredients of this band † differ but little from those of the *North* and *principal (veins) beds* on the same

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* *Ante, p.* 26.

† An average sample of this *jacotinga* afforded—

Peroxide of iron	78·0
Water	12·0
Oxide of manganese	1·5
Alumina	3·0
Talc	5·5
Gold............ a slight trace.	
	100·0

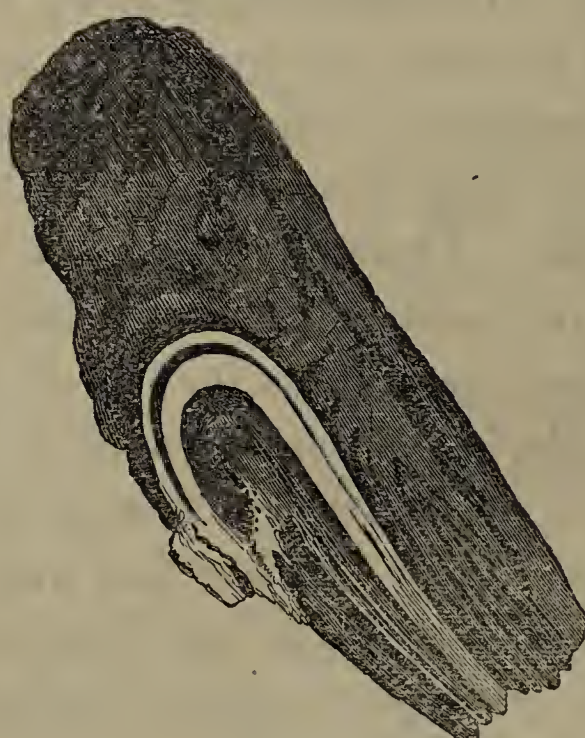
PERCIVAL NORTON JOHNSON, ESQ., F.R.S., F.G.S., &c., &c., MSS.

meridian; save that the earthy hydrous oxide of iron is, perhaps, somewhat more plentiful, and nests of pearl-white talc are larger and more numerous in it than in them. *Fig.* 24—sketched from nature—affords a better idea than mere verbal description can give, of the complicated mixtures and interlaminations of buff-coloured talc and iron-glance, which occur in the shallower parts of this bed.

Fig. 24.

GONGO SOCO. *New North (vein) bed.*

Transverse section.



Natural size.

(3—10.) Between *Blamey's* and *Collins's* shafts the *Cumba* formation contains several such bands || of iron-

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* "We have cut a vein in the Cumba formation which has given 4·5 oz. of "very fine gold."

Lyon, *Reports of the Imperial Brazilian Mining Association*, vii. p. 31.

"The Cumba mine has yielded a considerable quantity of valuable ore for the "*stamps;* but the produce for the *washing-house* has been very trifling until "lately; but between the 26th and 30th of October, 1840, upwards of 23 lbs. of "gold were extracted from the back of the 14-fathom level."

von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Ibid*, xxx. p. 85.

glance, brown iron-ore, earthy hydrous oxide of iron, manganese, and talc; but,—seldom more than a few feet in depth and never exceeding an inch in thickness—they disappear at the fourteen-fathom level.

(3—11.) On either side of both *shoots* in the auriferous (*vein*) bed, the *Gongo* iron-strata assume, for some distance, a thick lamellar structure and granular texture; but adjoining the smaller mass they are more granular,* whilst beside the larger they become softer,† than elsewhere; parallel with the former the *Cumba* formation also puts on a rather, though not an exactly, similar character.‡ These changes respectively begin and end at neighbouring—if not, indeed, at the very same—waves or ripples in the strata; which, as already shown, everywhere dip towards the east.§ In such rocks the *vein* north-west of *Morgan's* shaft ‖ and

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* *Table VIII.* column 3.

† A shaft commenced at the surface three weeks since is now about eighteen fathoms deep.

Lyon, *Reports of the Imperial Brazilian Mining Association*, v. p. 38.

At the *new adit* eight men have *driven* sixteen fathoms in fifteen days. I have promised them a reward if they complete thirty-five fathoms in the month; and they appear sanguine of success.—*Ibid*, p. 41.

The *cross-cut* at the *shallow adit* has been *driven* by three men forty-eight fathoms in eighteen working days.—*Ibid*, VI. p. 20.

‡ In the *Cumba adit* the ground is of so favourable a nature that we have assigned the men twenty fathoms for their month's work; and have promised them a premium of three *milreis* (about six shillings and nine pence), in addition to their ordinary wages, for every additional fathom they may drive.

Hocheder, *Ibid*, XVII. p. 97.

" Below the adit, the rock, although not very wet, is exceedingly soft."

Ibid, XVIII. p. 54.

In the *cross-cut* at the twenty-one fathom level towards *Cumba* the ground has become so very soft that we have been compelled to abandon it.

Harris, Collins, & Blamey, *Ibid*, XXV. p. 52.

§ *Ante*, pp. 259, 263, 264. ‖ *Ante*, p. 264; *Table VIII.* column 6.

the smaller *shoot* on the *principal* (*vein*) *bed* of the *Gongo* series,* as well as several shorter and narrower layers in the *Cumba* formation,† have all yielded gold on the same meridian.‡ In somewhat similar strata, the *principal*,§ *North*,‖ *New North*,¶ and other smaller (*veins*)** beds of the *Gongo* deposit,—all dipping east, —are likewise rich between the meridians of *Walker's* and *Curtis's* shafts.‡ In this part of its range, however, the *Cumba* series is entirely barren.††

(3—12.) Wherever hard, crystalline, massive iron-glance touches or approaches the auriferous bands, they cease to be productive.

On approaching the *Slide*,‡‡—which is composed of oxydulated iron and talc,—the *North* (*vein*) *bed* partakes its ingredients, and conforms to its smaller inclination,§§ but no longer yields gold. For of every auriferous band in both series, the highly inclined

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* *Ante*, p. 263; *Pl. IV. Fig.* 2.

† *Ante*, p. 268; *Table VIII.* column 6; *Pl. IV. Fig.* 3.

‡ Carne, *Cornwall Geol. Trans.*, III. p. 78. Henwood, *Ibid*, V. pp. 215, 233. *Ante*, p. 258, Note ‖.

§ *Ante*, p. 264; *Table VIII.* columns 12, 15, 18; *Pl. IV. Fig.* 2.

‖ *Ante*, p. 266; *Table VIII.* columns 15, 18.

¶ *Ante*, p. 267; *Table VIII.* columns 15, 18.

** *Table VIII.* columns 12, 15, 18; *Pl. IV. Fig.* 3.

†† Hocheder, *Reports of the Imperial Brazilian Mining Association*, XVII. p. 83. Tregoning, Harris, Collins, & Bray, *Ibid*, XXI. pp. 81, 105; XXII. pp. 98, 102. Harris, Bray, Collins, Blamey, & Pengilly, *Ibid*, XXVII. pp. 51, 56.

‡‡ *Ante*, pp. 252, 266; *Table VIII.* columns 3, 15.

§§ Near the *Slide* the *North vein* has altered its dip and nature; and hitherto it has been poor.—Hocheder, *Reports of the Imperial Brazilian Mining Association*, XVII. p. 72.

Tregoning, Harris, Jennings, & Bray, *Ibid*, XVIII. p. 94. *Table VIII.* Note *f*.

portions are most, whilst the flattest are least, productive.*

(3—13.) But, although a general resemblance prevails throughout the *North* and *New North (veins) beds,*—both *shoots* in the *principal (vein) bed,*—and several smaller members of the *Cumba* formation,† gold abounds only in certain portions; which—difficult as it is to describe them—are easily recognised by a practised eye.‡ The history of *Gongo Soco*,§ therefore, mentions no mass *(bunch)* of gold discovered by mere chance; although appearances, favourable at first, have—as in the mines of other countries—sometimes led to disappointment.

The richest bodies of *Jacotinga* are seldom more than a few feet in length and depth; but, between *Pengilly's* and *Duval's*, as well as between *Walker's* and *Bayly's*, shafts the *bunches* have been very numerous.

Near the middle of each bed † the matrix, already described, encloses rough *(nuggets)* lumps, usually

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* From the shallow-adit to the four fathom level, the *vein* dips faster than usual, and has a kindly appearance: it now yields rich *prills*.

LYON, *Reports of the Imperial Brazilian Mining Association*, VI. p. 54.

Throughout the mine gold is most plentiful in those parts of the *vein* which are nearest to the perpendicular.

JENNINGS, COLLINS, HARRIS, BRAY, & JEFFERY, *Ibid*, XIV. p. 66.

At the twenty-seven fathom level near *Macfarlane's* shaft the strata in the western part of the works have a very flat inclination towards the south, and appear rather unpromising * * * * Eastward however the vein has held down to the *back* of this level, and has been very productive.

HOCHEDER, *Ibid*, XVI. p. 66.

Thomas, *Report on a Survey of the Mining District from Chacewater to Camborne*, p. 20. Henwood, *Cornwall Geol. Trans.*, V. p. 231. *Ante*, p. 82, Note *.

† *Ante*, pp. 263—268.

‡ Duval, *Reports of the Imperial Brazilian Mining Association*, XXIX. p. 23.

§ *Ibid*, I.—LXII.

but a few ounces,* though here and there two or three pounds,† and, in an instance or two, of still greater ‡ weight. Some of these are isolated; others, at unequal intervals, are either irregularly clustered, or united by thin laminæ and reticulated threads; but all are of gold. Certain broad parts of every (*vein*) bed have, at times, contained two or three parallel groups§ of this description; which have, now and

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* Lyon, *Reports of the Imperial Brazilian Mining Association,* IV. p. 48; VI. pp. 45, 49, 58; VIII. pp. 30, 33, 39. Trebilcock, Prideaux, Hambly, & Jennings, *Ibid,* VIII, p. 71.

† Lyon, *Ibid,* IV. p. 20; VII. pp. 35, 56; VIII. pp. 35, 54, 58. Skerrett, *Ibid,* XIV. p. 42.

‡ "Of the *prills,* now sent as specimens, one—which still weighs more than "twenty-one lbs.—would have been more than thirty lbs., but a great part "crumbled off in the washing."—Skerrett, *Ibid,* XIV. pp. 43, 49.

"A peculiarity observed in the *bunch,*" west of *Morgan's* shaft, "is the lumpy "nature of the *work* of which it is composed, and the unusual size of its *prills:* "one of these was 13 inches long, from 3½ to 5 inches broad, and from ¼ to 1½ "inch thick, weighed when roughly washed 14 lbs. 4 oz. 15 dwts., and produced, "after being pounded, 13 lbs. 1 oz. 19 dwts. 4 grs. of gold, in which one solid, "pure, piece weighed 1 lb. 3 oz. 16 dwts."

Duval, *Ibid,* XXVII. p. 25.

§ Our gold has been chiefly obtained from a *branch* beneath the vein lately worked in the back of the thirty-four fathom level east of Lyon's shaft. Where first seen, the *branch* bore nearly north and south; but within a short distance its direction changed, and it is now nearly parallel to, and about ten feet north of, the vein from which it separated. This is by no means an unusual occurrence; for *branches* parallel to those first worked have been frequently discovered.

Harris, Jennings, & Bray, *Ibid,* XVIII. p. 65.

At the thirty-four fathom level east of *Gibson's* shaft, a *branch* about four feet south of the North vein yielded on the 18th and 19th of February, 1836,—219 lbs. 4 dwts. 12 grains of gold.—Morgan, Hickson, Tregoning, Harris, Jeffery, Bray, Jennings, & Collins, *Ibid,* XX. pp. 38, 39, 81, 83, 86; XXI. pp. 18, 68, 69, 123; XXX. p. 82.

On the 7th of February, 1840, two men extracted in three hours 105 lbs. of gold from a *vein* in the north *wall* of the old works at the thirty-four fathom level east of *Curtis's* shaft.— Duval, Harris, Bray, Collins, Blamey, & Pengilly, *Ibid,* XXVIII. pp. 37, 64; XXIX. pp. 23, 37, 40, 65; XXX. p. 82.

Whilst opening a second level between *Curtis's* and *Gibson's* shafts, a *side-*

then, lain within so narrow a compass, that they were wrought in the same *(level)* gallery.* *Nuggets* are common near the centres of aggregations; *foliæ* † towards their circumferences.

But whilst clusters, such as these, form a striking characteristic; — smaller *nuggets (prills),* ‡ flakes, threads, and granules,§—slightly coherent, or—more

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vein was discovered; which, in May and June, 1842, yielded 303 lbs. 7 oz. 13 dwts. of gold.—Crickitt, *Ibid,* xxxiii. pp. 1, 4.

* "As we have had three confused branches in the fourteen fathom end for "some days, I suspect, as they join, we shall come to a good bunch; of which "we have already some indications."

Lyon, *Reports of the Imperial Brazilian Mining Association,* vii. p. 46.

"In the bottom of the twenty-seven fathom level, east and west of *Lyon's* "shaft * * * we have sometimes had two, sometimes three productive veins.

Jennings, Harris, Bray, & Jeffery, *Ibid,* xiii. p. 56.

"The workings in the shallower part of the mine have only been carried on "from two to three feet in width, because there was but one vein to follow; in "working deeper, several veins have been met with, but they were diminishing "in richness. The works in the back of the thirty-four fathom level are now "from seven to eight feet in breadth, in order not to miss any vein which may "exist, either in the *foot,* or the *hanging-wall,* of the bed."

Hocheder, *Ibid,* xvii. p. 79.

† The late Captain John Luke, MSS.

At *Taquaril* near Sabará strata of schistose iron-glance, enclosing, in some places, minute, conformable bands of quartz, are divided by thin beds of buff-coloured talc; and these are interlaid by plates of gold; which—frequently several inches in length and breadth, though seldom thicker than paper,—often exhibit parallel striæ, similar to those observed in the larger deposits of *Morro Velho, Pitangui, Agoa Quente,* and *Gongo Soco,* and in *slickensides* elsewhere.

John Morgan, Esq., MSS.

‡ We have cut a strong branch of gold in the middle adit; but—owing to the unusually wet state of the *level*—we cannot see it. The vein-stuff washed to-day has given nearly two pounds of gold; we have for some time had *prills* as large as half-almonds, we now have them of an ounce weight.

Lyon, *Reports of the Imperial Brazilian Mining Association,* viii. p. 39.

§ Between the seven and fourteen fathom *levels* the *branch* has a very peculiar appearance, the gold lying in it in fine dust, but few *prills* occurring; decomposed yellowish talc and reddish-brown manganese, forming to the breadth of a span in some places, and then again diminishing to an inch in thickness. The whole of this is rich in gold, and I saw a miner's hatful broken underground which yielded 27 lbs. 7 oz. 14 dwts. of dust.

Ibid, viii. p. 61; *Table VIII.* Note *ii.*

A *hat-cap* of ordinary size heaped with coarse ore is about 0·142857 cubic foot

frequently–isolated in the surrounding matrix,–furnish the chief riches—of this formation. Grains, particles, and—sometimes—small *nuggets* occur in numbers gradually diminishing towards the confines of every *bunch;* * on both sides of large masses, however, adjoining strata are, for short distances, also thinly sprinkled with gold.†

The following extracts from accounts kept at the mine show how unequally gold is distributed, as well in the *bunches,* as in the formation generally.

	Consecutive days.		
Dates.	*Washing-house.* lbs. *(Troy).*	*Stamps.* lbs. *(Troy).*	Totals. lbs. *(Troy).*
1828. Feb. 14th	9·601	—	9·601 ‡
15th	72·121	—	72·121
16th	17·680	—	17·680
1829. Jan. 22nd	9·418	—	9·418 §
23rd	67·213	—	67·213
24th	10·590	—	10·590

* In parts of the productive layers where no gold is visible by the naked eye, it exists disseminated through the jacotinga.

Hocheder, *Reports of the Imperial Brazilian Mining Association,* xv. p. 55.

Most of the gold lately obtained has been from the back of the thirty-four fathom level east of Gibson's shaft, where the auriferous stratum is occasionally divided into several layers; in which, although the gold is not always perceptible, the jacotinga for the stamps is richer than that from other places.

Ibid, xvi. p. 60.

Of late the greatest part of our produce for the washing-house has been obtained from the back of the thirty-four fathom level near Curtis's shaft. Goldsmid's stamps, supplied from these workings, yielded during the past month (February, 1840) about fifty-nine pounds of gold.

Harris, Bray, Blamey, & Pengilly, *Ibid,* xxix. p. 37.

† In the back of the thirty-four fathom level east of Curtis's shaft the vein has been very rich, and the stuff on either side of it has yielded a large produce at the stamps.—Harris, Jennings, Collins, & Bray, *Ibid,* xv. p. 44.

‡ *Ibid,* iv. p. 74; v. p. 98. § *Ibid,* vii. p. 117.

Consecutive days, continued.

Dates.	*Washing-house.* lbs. *(Troy).*		*Stamps.* lbs. *(Troy).*	*Totals.* lbs. *(Troy).*
1829. Feb. 24th	28·916		—	28·916 *
25th	81·833	127·853 †	—	81·833
26th	46·020		6·225	52·245
Sept. 22nd	37·680	516·654 †	—	37·680 ‡
23rd	137·000		9·000	146·000
24th	69·242		5·500	74·742
25th	140·958		9·166	150·124
26th	68·083		3·000	71·083
28th	63·691		—	63·691
29th	13·870		—	13·870
1830. Jan. 20th	13·714		—	13·714 §
21st	77·741	140·821 ‖	—	77·741
22nd	63·080		—	63·080
1831. April 14th	2·191		—	2·191 ¶
15th	18·772		—	18·772
16th	35·786		—	35·786
1832. Nov. 22nd	5·810		2·566	8·376 **
23rd	30·951		6·554	37·505
24th	97·840 ††		2·588	100·428
26th	11·158		1·679	12·837
1836. Feb. 16th	—		1·022	1·022 ‡‡
17th	23.893		—	23·893

* *Reports of the Imperial Brazilian Mining Association*, VII. p. 118.
† *Table VIII.* column 15; *Postea*, p. 279.
‡ *Reports of the Imperial Brazilian Mining Association*, VIII. p. 121.
§ *Ibid*, IX. p. 75.
‖ *Table VIII.* column 15; *Postea*, p. 280.
¶ *Reports of the Imperial Brazilian Mining Association*, XI. p. 91.
** *Ibid*, XIV. p. 117.
†† *Table VIII.* column 18; *Postea*, p. 280.
‡‡ *Reports of the Imperial Brazilian Mining Association*, XXI. p. 123.

Consecutive days, continued.

Dates.		Washing-house. lbs. (Troy).	Stamps. lbs. (Troy).	Totals. lbs. (Troy).
1836.	Feb. 18th	116·583 } 21·9018 *	—	116·583
	19th	102·435 }	—	102·435
	20th	11·353	5·827	17·180
	22nd	2·025	2·835	4·860
1839.	Jan. 7th	0·341	1·930	2·271 †
	8th	20·302	3·772	24·074
	9th	9·786	0·804	10·590
	10th	—	0·834	0·834
1840.	Feb. 6th	—	0·374	0·374 ‡
	7th	28·724 §	0·250	28·974
	8th	90·020 §	3·246	93·266
	10th	4·062	0·853	4·915
	11th	—	0·728	0·728
		Consecutive months.		
1828.	February	256·562	—	256·562 ‖
	March	40·179	—	40·179
1829.	August	219·315	37·124	256·439 ¶
	September	711·648	47·410	759·058
	October	270·277	30·550	300·827
1836.	January	4·647	28·256	32·903**
	February	301·558	43·363	344·921
	March	17·767	61·224	78·991

* *Reports of the Imperial Brazilian Mining Association*, XX. pp. 38, 39, 81, 83; XXI. pp. 60, 69, 73, 123; *Table VIII.* column 21; *Postea*, p. 280.

† *Reports of the Imperial Brazilian Mining Association*, XXVII. p. 66.

‡ *Ibid*, XXIX. p. 65.

§ *Ibid*, XXIX. pp. 23, 65; *Table VIII.* column 18; *Postea*, p. 280.

‖ *Reports of the Imperial Brazilian Mining Association*, IV. p. 74; V. p. 98; *Table IX.* columns 11—13.

¶ *Reports of the Imperial Brazilian Mining Association*, VIII. p. 121; *Table IX*, columns 29—37.

** *Reports of the Imperial Brazilian Mining Association*, XXI. p. 123; XXVII. p. 66.

Consecutive months, continued.

Dates.	*Washing-house.* lbs. *(Troy).*	*Stamps.* lbs. *(Troy).*	Totals. lbs. *(Troy).*
1840. January......	5·355	46·184	51·539 *
February.....	191·231	76·114 †	267·345
March.......	14·424	44·769	59·193

Consecutive years.‡

1827............	2,010·011	—	2,010·011
8............	1,062·200	—	1,062·200
9............	3,807·089	383·884	4,190·973
1830............	2,804·558	235·957	3,040·515
1............	2,434·414	597·463	3,031·887
2............	2,756·249	1,445·977	4,202·226
3............	1,790·534	1,197·922	2,988·456
4............	934·348	719·252	1,653·600

(3—14.) From 1826 to 1856 the Imperial Brazilian Mining Association obtained §—

in clusters, *nuggets,* and other coarse gold; treated by hand at the *washing-house*	23,381·251 lbs.‖	or 0·677 of the entire produce;
in smaller grains and particles extracted from the *jacotinga* by *stamping*	11,146·847 ,, ¶	,, 0·323 ,,
Total............	34,528·098 lbs.‡	

Rather more than two thirds of the gold occurred, therefore, in masses, plates, and threads; whilst somewhat less than one-third was disseminated, in grains and particles, through the adjoining matrix.

* *Reports of the Imperial Brazilian Mining Association,* XXVII. p. 66; XXIX. p. 65.

† Inferior ore is seldom or never *stamped* or washed the day it is broken in the mine.

Postea, p. 276, Note *.

‡ *Table IX.* columns 44—46.

§ *Reports of the Imperial Brazilian Mining Association,* I.—LXII.

‖ *Table IX.* column 44, Note. *l*

¶ ,, ,, 45, ,, *m.*

Numbers of *prills* and quantities of rich *Jacotinga*, however, were stolen by the workmen; * who—somewhat insufficiently superintended,†—for several years, brought to the surface in their *hat-caps*, ‡ the gold they had broken in the mine.

The positions and relations of the several *bunches* are set forth in *Table VIII.;* the proportions of *nuggets* and other rough gold they afford, are shown in the following columns :—

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* One of our miners, who was a few days since detected whilst washing a large quantity of gold, in a most sequestered place about four miles from the mine, has been handed over to the authorities. * * * On searching the place a large canister of rich unwashed ore was traced out by scraps of paper and old rags, in various stages of decay, denoting the length of time this nefarious traffic must have been carried on.

Skerrett, *Reports of the Imperial Brazilian Mining Association,* xi. p. 27.

Our stamps have been robbed but four times in the last two years. * * * The infamous gang, who found their way into your service, formerly contrived to plunder them frequently.—*Ibid,* xiii. p. 30.

The last remittance includes nearly a pound of gold seized near the robbers' cave. It has been returned by the authorities.—*Ibid,* xiv. p. 49.

† "Both captains and miners were so anxious to tear out the gold, that the "14-fathom level was in an instant filled with men; and such was the eagerness "of the crowd, that it was utterly impossible for all to squeeze into the end; "some of them in consequence amused themselves, by way of recreation, in "taking out good *work* from the 7 fathom level."—Lyon, *Ibid,* vi. p. 58.

‡ "On my return I found * * * one of the miners with such a hat of pro-"duce! from the end of the 14 fathom level."

Ibid, vi. p. 58; vii. p. 27; viii. pp. 34, 61.

"To bring up four or five hats full of ore occupied the miner an hour and a "half, which might have been spent in labour * * * I have therefore provided "leather-lined baskets five or six times the size of a hat and secured with pad-"locks. These can be drawn up *winzes* and shafts without loss, whilst the "miner continues his work."—Skerrett, *Ibid,* ix. pp. 26, 28.

"Hats shall no longer be used * * * although the miners assign as a reason "for still bringing one occasionally, their desire to show it themselves when "good."—*Ibid,* xi. p. 28.

"The ore which was formerly left in hats when brought up is now deposited "in a large double-locked chest."—*Ibid,* xiii. p. 29.

Locality.	Levels. fms.	Gold. *Bunches* of	lbs.	Proportion of extracted.
		SMALLER OR WESTERN *SHOOT.*		
W. of *Morgan's* shaft	7	A single mass	14·391*	—
W. of *Duval's* „	7	Extracted .... in seven days..	115·221†	—
„	14	....		Small *bunches*...... 0·004840—0·027904†
		LARGER OR EASTERN *SHOOT.*		
Between *Walker's* „ and *Aveline's* „	surface to 3	Extracted .... 1824, Feb. & March	531·192‡	Small beds adjoining the rich *bunch* .... 0·003273—0·005949‡
W. of *Da Gama's* „	7	„ from *end* of *level* only, 1829, Jan. 7th, .. in the day .	20·000§	—
„	14	„ „ April 1st, .. in the day .	32·814§	—
W. of *Esperança* „	7	„ from part of bed 7 feet long and 6 feet deep....	53·000‡	.... 0·029683‡
	7	A miner's *hat-cap*** of ore yielded........................	11·000‡	.... 0·289429‡
E. of „ „	7	„ „	8·000‡	.... 0·210494‡
„	7	„ „	10·000‡	.... 0·263118‡
„	7	Each square fathom of the bed yielded	5·000‡	—
W. of *Stokes's* „	7	Extracted by one man, ... 1827, Aug. 27th, ... in the day .	40·118‡	—
„	7	„ two men, ... Sept. 5th, ... in the day .	31·869‡	—
W. of *John's* „	7	A miner's *hat-cap*** of ore afforded........................	11·502§	.... 0·302585‡
W. of *Lyon's* „	14	Extracted, from *end* of *level* only, 1829, Jan. 23rd, .. in the night.	67·213‡	—
„	14	„ .... January, ... in six days .	143·804‡	—
„	14	„ .... Feb. 25th, 26th, in two days.	127·853‡	—

Locality.	*Levels.* fms.	Gold. *Bunches* of				Proportion of extracted.	
		LARGER OR EASTERN *SHOOT*, continued.			lbs.		
W. of *Lyon's* shaft	14	Extracted	1829, September,	in six days	516·654‡	—	
”	14	”	1830, January,	in two days	140·821‡	—	
”	14	A miner's *hat-cap*** of ore afforded, 1830, Jan. 21st,			27·641‡		0·521123‡
”	21					Small quantities	0·029042‡
”	27					”	0·041046‡
E. of ” ”	34	Extracted	1832, Nov. 24th,	in one day	97·840‖	—	
”	34	A single mass			30·000‖	—	
Curtis's ”	34	Extracted by two men	1840, Feb. 7th,	in three hours	105,000‖	The entire mass	0·093567‖
E. of ” ”	41	”	1841, May and June		303·637‖	Great part	0·004648‖
E. of *Gibson's* ”	34	”	1836, Feb. 18th, 19th,	in two days	219·018¶	The entire mass	0·036596¶
”	34					Portions of it	0·056006¶
”	41					A small mass	0·043085¶
”	41	Extracted	1844, Jan. and Feb.		160·300¶	Portions	0·008630¶

NOTES to pp. 279—80.

* *Table VIII.* column 6.	‖ *Table VIII.* column 18.
† ” ” 9.	¶ ” ” 21.
‡ ” ” 15.	** ” Note *w*; *Ante*, p. 27, Note ‡.
§ ” ” 12.	

The eastern are the most deeply seated *bunches*.

From *Jacotinga* in which scarcely a particle could be seen by the unaided eye, the undermentioned proportions* of gold-dust were obtained at the *Stamps*.

Date.	Locality.	Proportion of gold extracted.
1832.	Beds *(veins)* and *bunches* from various *levels* in different parts of the mine	0·00001234†
1833.	.... „ .... „	0·00002051‡
1834.	.... „ .... „	0·00000557§
1836.	.... „ .... „	0·00000408‖
1844.	.... „ .... „	0·00000105
1845.	.... „ .... „	0·00000088
1850.	.... „ .... „	0·00000076¶
1851.	.... „ .... „	0·00000044**
—	48-fathom *level* near *Vesey's* shaft........	0·00000042††

The *bunches*, of which the broader and more highly inclined central parts give from (0·302585 ‡‡ to 0·521123) one-third to one-half their weight of metal, gradually diminish in width, inclination, and quality, towards their circumferences; and, at length, merge in the still thinner, flatter, and less productive portions of the (*veins*) beds, where two million three hundred thousand of matrix yield (0·00000042†† to 0·00000044**) a unit of gold. The poorest ores, how-

* *Table VIII.* columns 15, 21; *Table IX.* column 7.

† Skerrett, *Reports of the Imperial Brazilian Mining Association*, XIII. p. 36.

‡ Hocheder, *Ibid*, XV. p. 64.

§ *Ibid*, XVII. pp. 72—122, 143—148; XVIII, pp. 41—57, 111—113.

‖ F. X. Hocheder, *Ibid*, XXII. p. 74.

¶ Hitchens, *Ibid*, L. p. 3. ** *Ibid*, LI. p. 4; LII. pp. 7, 10.

†† Tregoning, Harris, Bray, & Collins, *Ibid*, XXII. p. 120.

‡‡ Lyon, *Ibid*, VIII. pp. 34, 61; *Table VIII.* column 12; *Ante*, p. 276.

ever, are wrought only whilst they afford traces of those rich *bunches*, which are peculiar to the *Jacotinga*.

For ores of qualities so unlike, experience dictates the different modes of treatment.*

(3—15.) The *Cumba* formation contains several short, narrow *(veins)* beds; which afforded small *bunches* of gold between *Blamey's* and *Collins's* shafts at the fourteen fathom level, but yielded mere scattered particles at greater depths.†

The *Gongo* formation includes the *Principal, North, New North*, and several smaller, *(veins)* beds, already described.

The *New North (vein) bed* crops out at the surface north of *Walker's* shaft; and—dipping endlong towards the east—disappears at the thirty-four fathom level near *Aveline's*.‡

The *North (vein) bed* has no existence above the fourteen;—from the neighbourhood of *Walker's* shaft at that *level*, however, it declines in like manner to the forty-one east of *Gibson's;* and there dies.§

The *principal* (*vein*) *bed* contains two large auriferous *(shoots)* masses; connected, near the middle of the mine, by a barely perceptible rib of inferior ore.‖ The smaller or western *shoot* was successfully wrought from its outcrop on the mountain-side west of *Pengilly's*

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* Hocheder, *Reports of the Imperial Brazilian Mining Association*, xv. p. 74. Henwood, *Proceedings of the Royal Geological Society of Cornwall*, 1848. *Table IX*. Note *l*.

† *Ante*, p. 268; *Table VIII*, column 6; *Pl. IV. Fig* 3.

‡ „ p. 267; „ columns 13—18.

§ „ p. 266; „ „ 13—21.

‖ „ p. 264; „ „ 7—9; *Pl. IV. Fig*. 2.

shaft, to the fourteen fathom level east of *Duval's;* towards the twenty-one, however, it became small, flat, poor, and unkindly.*

The larger or eastern *shoot* † was rich, beyond comparison, from the surface ‡ to a depth of twenty-five fathoms; but thence to about thirty it declined. At the thirty-four fathom *level,* however, it was once more very productive; and about the forty-one large *bunches* were still frequent. Towards the forty-eight these were both smaller and less numerous; whilst at, and somewhat below, the fifty-five, thin plates and dendritic flakes were obtained. From the sixty-two downward small isolated bits occurred at distant intervals; and at the seventy the *Jacotinga*—already dwindled to a narrow seam—afforded but a few widely-scattered particles of gold.§

Notwithstanding the ores were so soft || that the *back* of one (gallery) *level* was in some measure exhausted, before the shaft had reached another; ¶ the upper (14,

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* *Ante*, p. 263; *Table VIII.* columns 4—9; *Pl. IV. Fig.* 2.

† „ p. 264; „ „ 10—21; „ .

‡ A tradition still lingers in the neighbourhood that this deposit was found during examinations prompted by the discovery of a solid water-worn mass of gold, which weighed thirteen pounds, embedded in gravel, at the confluence of the Gongo Soco and Socorro waters, near Taboleiro.

The Imperial Brazilian Mining Association extracted from *Gongo Soco* during

the first day	they worked	0·589 lbs.	of gold;
„ week	„	4·896 „	„
„ month	„	83·652 „	„
„ year	„	672·670 „	„

Reports, I. pp. 113, 115, 124, 125; II. pp. 69—77; III. pp. 69—71.

§ *Ante*, pp. 264, 280, 281. *Tables, VIII.* columns 10—21; *IX.* columns 2—46. *Pl. IV. Fig.* 2.

|| *Ante*, p. 269.

¶ "As soon as the shaft is sunk a sufficient depth * * * a *level* is commenced,

21, 27, and 34 fathom) *levels* were not entirely gleaned when the mine had attained (the 70) its greatest depth. Of the quantities obtained from the several (*veins*) beds, at different *levels*, in the same times, no accounts remain. As, therefore, our only available *data* assign to the deeper parts an undue value,* we have no means of correction: the following attempt to ascertain the relative proportions in which gold occurs at various depths in this formation, must be regarded as but a rough approximation.

The auriferous *Jacotinga* was wrought, solely by European miners, with the *pick* alone.†

Depth. ‡ fms.	Gold, Average annual quantity of, extracted by each European. lbs. (*Troy*).§	Gold, Proportion of.
7 to 21 ..	.... 20·871	...... 1·
21 „ 41 ..	.... 19·496	...... 0·790
41 „ 55 ..	.... 9·400	...... 0·450

As little gold was found below the fifty-five fathom *level*, it is useless to extend this enquiry.

" which proceeds both eastward and westward on the lode. * * * As the work-" man goes forward, another is employed to *stope* or dig down the ore above the *level*, and as he makes progress, a third follows him in another *stope*; * * * meantime the shaft continues to be sunk, and becomes deep enough for other *levels* before the ore above the first is exhausted."

Carne, *Cornwall Geol. Trans.* iii. p. 70.

* The richest *bunches* in the western *shoot* were obtained at the seven fathom *level* near *Morgan's* and *Duval's* shafts, whilst *Vesey's* was being sunk below the forty-eight.—*Table IX.* columns 6, 9; *Ante*, p. 279.

† Throughout Gongo the wettest, softest, and most treacherous part of the formation accompanies the gold.

Lyon, *Reports of the Imperial Brazilian Mining Association*, viii. p. 27.

‡ *Table IX.* column 2.

§ „ columns 3, 46.

From an early part of the last century* it has been believed, by Brazilian miners, that the shallower were the richer parts of their gold-formation;† an opinion which deeper and more extended working, as well under German as under English direction, has not contravened.‡

(3—16.) Touching the quality of the gold found at different depths,§—our information || relates only to that obtained from 1833 to 1844 between the forty-one and the seventy; but to the produce of these and other *levels*, at earlier and later periods, it has—unfortunately—no reference.

Depths.	Quality (*toca*) of Gold. Actual.		Comparative.
fms.	carats.	grains.	
41 to 48..	 21	0·448	.... 1·
48 „ 70..	 20	1·774	.... 0·968

The finer gold, therefore, appears in the upper parts of *Gongo Soco*; but in the lower of *Morro Velho*.¶

Whether the ores were wrought between the forty-one and forty-eight, or the forty-eight and seventy, they were mixed, during reduction, with much the same proportions of those broken at the same time in the shallower *levels*.** But whether the larger

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* Von Eschwege, *Pluto Brasiliensis*, pp. 280—284.

† Southey, *History of Brazil*, III. pp. 56, 826. Walsh, *Notices of Brazil*, II. p. 130.

‡ *Ante*, pp. 179, 201—203, 230—235, 241, 284.

§ *Table IX.* column 47.

|| Percival Norton Johnson, Esq., F.R.S., F.G.S., &c. MSS.

¶ *Ante*, p. 205.

** *Ante*, p. 283.

(nuggets) lumps differ, in *(toca)* quality, from the smaller grains of gold, scattered through the adjoining matrix, is unknown.

(3—17.) From gold extracted at different depths, and *(dressed)* washed at the mine, the undermentioned proportions of other scarce metals were afterwards separated.*

Depths. fms.	Unrefined Gold.	Proportions of Silver.	Platina.	Palladium.	Copper.†
41..	1·	0·058814	0·001276	0·038929	0·019444
48..	1·	0·054759	0·000711	0·041974	—‡
55..	1·	0·047614	0·000407	0·042709	—‡
62..	1·	0·044884	—	0·048054	0·037413
Means.	1·	0·052991	0·000811	0·042100	0·025374

From the forty-one fathom *level* downward, therefore,
the proportion of Silver .... diminished;—
,, Platina§ .. ,, , and ultimately disappeared;—but
,, Palladium . increased;—and so did
,, Copper.

(4.) In several parts of the mine *cross-veins*, from one-eighth to, perhaps, three-quarters of an inch wide, bear a few degrees on either side of the meridian. Their range—whether horizontal or vertical—rarely exceeds a fathom; whilst towards their circumferences they

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* *Reports of the Imperial Brazilian Mining Association*, XVI—XXXI., Financial Statements. *Table IX.* columns 47—50.

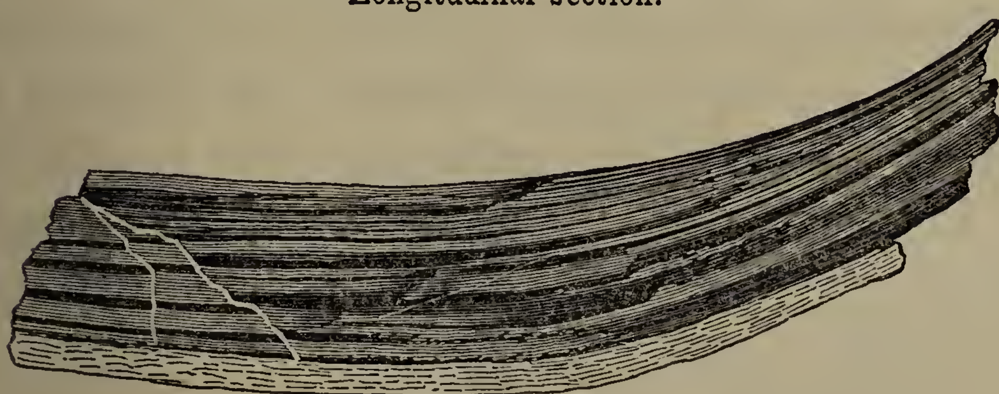
† Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., MSS.

‡ Copper—less valuable—was taken less care of than the rarer metals.

§ Several tons of Australian tin-ore,—previously freed from all trace of gold by amalgamation,—yielded, on repeated analysis, small proportions of platina.
John Michell, Esq., of Calenick, MSS.

dwindle,*—merge, at times, in congenial quartzose bands of the *Itabirite*† (*Fig.* 25),—and soon disappear. Some *cross-veins* merely sever, whilst others dislocate, the strata. Productive portions of the *Principal (vein) bed*, at the seven fathom *level* near *Williams's* shaft,‡ and within the *horse* at the forty-one east of *Gibson's*,§ are simply intersected; but, at an intermediate spot near *Lyon's* shaft,‖ several thin bands are displaced (*Fig.* 25).

Fig. 25. GONGO SOCO.
Dislocated strata near Lyon's shaft.
Longitudinal section.



Scale—one-fourth.

The displacements—seldom more than a quarter of an inch in extent—are largest near the middle of the *cross-veins*, and diminish gradually towards their extremities, where the strata maintain an undisturbed continuity. In all cases, however, those portions of rock which form the *(hanging-walls)* upper sides, occupy higher relative positions than their counterparts in the (*foot-walls*) lower sides of the *cross-veins*.¶

* Henwood, *Cornwall Geol. Trans.* v. p. 381; *Ante*, p. 226.
† *Ante*, p. 248.
‡ *Table* VIII. column 12.
§ „ „ 21.
‖ „ „ 15.
¶ *Ante*, p. 226, Note †.

These—like the *cross-veins* at *Agoa Quente**—consist chiefly of quartz; sometimes mixed with iron-ore, but never with gold.

The mine—laid open by shafts, *levels*, and *winzes*,†—was drained by (*drawing*‡ and *plunger-lifts*§) lifting and forcing pumps; of which the columns were iron-bound wooden pipes made on the spot; but—as cast-iron and brass were not manufactured in the Province, and the roads were unsuited to wheeled carriages—the *working-barrels*,‡ *clack-seats*,‡§, *plunger-cases*,§ *stuffing-boxes*, and *glans* § were imported from England in pieces of about (*five arrobas*) one hundred and sixty pounds each,‖ and taken from Rio de Janeiro to the mines on mules. Gudgeons, cranks, *strapping-*

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* *Ante*, p. 248.

† Carne, *Cornwall Geol. Trans.*, III. p. 70. Taylor, *Phil. Mag. & Annals*, VI. p. 285. Henwood, *Quarterly Mining Review*, I. (1830) p. 405; *Cornwall Geol. Trans.* V. *Pl. I. Fig.* 9—*IV. Fig.* 2. Burr, *Practical Geology*, p. 285, *Pl.* 3, 4. *Penny Cyclopædia*, XV. p. 238. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 556, *Pl.* 7, 8, 9. Combes, *Traité de l'Exploitation des Mines*, II. p. 152, *Pl. XX. Fig.* 2. *Encyclopædia Britannica*, 8 Edition, XV. p. 224, *Fig.* 3. *Ante*, p. 145, Note ‡; *Pl. IV. Fig.* 2, 3.

‡ Taylor, *Records of Mining*, I. pp. 129, 130, *Pl. XIII. XIV. Fig.* 1. *Quarterly Mining Review*, II. pp. 307, 308, *Pl. XIII. XIV. Fig.* 1. *Annales des Mines*, 3me Série, I. p. 218. Combes, *Annales des Mines*, 3me Série, V. p. 610, *Pl. XI. Fig.* 11. *Traité de l'Exploitation des Mines*, III. pp. 347—359, *Pl. LIII. Fig.* 16. Henwood. *Transactions of the Institution of Civil Engineers*, II. p. 57; *London & Edinburgh Phil. Mag.* XIV. p. 488.

§ Carne, *Cornwall Geol. Trans.* III. p. 59. Taylor, *Records of Mining*, I. pp. 129, 134, *Pl. XIII. XIV. Fig.* 2,—*XV. Fig.* 1, 2, 3. *Quarterly Mining Review*, II. pp. 306, 312. *Annales des Mines*, 3me Série, I. p. 222. Combes, *Annales des Mines*, 3me Série, V. p. 609, *Pl. XI. Fig.* 10; *Traité de l'Exploitation des Mines*, III. pp. 359—362, *Pl. LIV. Fig.* 1. Henwood, *Trans. Institution of Civil Engineers*, II. p. 57; *London & Edinburgh Phil. Mag.* XIV. p. 488.

‖ In one instance an English founder's inattention to this requisite limitation, caused the *extra* expense of land-carriage to exceed the first-cost of his goods.

plates, and *stamp-heads,* of wrought-iron, are made in the neighbourhood.*

From 1st January, 1826, to 31st December, 1856, the Imperial Brazilian Mining Association

Received †

Capital from shareholders, at the commencement		£200,000	
„ „ , subsequently		29,874	
			£229,874
Sundries		£ 226	
„ Proceeds of unallotted and relinquished shares.		1,905	
„ Fees on transfer of shares		3,812	
„ Interest		34,404	
			40,347
Gold-dust sold, proceeds of		£1,118,195	
„ paid Brazilian Government for Provincial Duty, value of	£288,738		
„ Export Duty, „	20,141		
		308,879	1,427,074
			£1,697,295

Paid †

Purchase of Estates, Mine, Slaves,‡ &c.		£100,808
„ Machinery, tools, cattle, food, &c.	£451,995	
Salaries and wages	432,942	
		884,937
Sundries	£ 522	
Loss on unallotted and relinquished shares	796	
„ by failure of Bankers	1,889	
		3,207
Brazilian Government, in gold dust and in money, for Provincial Duty..	£310,777	
„ „ Export „ ..	22,403	
		333,180
Expenditure at *Gongo Soco*		£1,322,132
Expended in other mines	£25,649	
Balance, cash on hand..............................	764	
		26,413
Profit to the shareholders..		348,750
		£1,697,295

* *Ante,* p. 219. † *Table IX.,* columns 52—73.

‡ (*a*). Of the slaves bought, with the mine and estate of *Gongo Soco* by the

Imperial Brazilian Mining Association, of the Capitaõ Mór Joaõ Baptista Ferreira de Souza Coutinho, we have no record; but, with those afterwards purchased of native *traders*, and children born in the mean time, they numbered in

Years	Adults bought.			Children			Children's children			Adults hired			Totals
	Men	Women	Total	Boys	Girls	Total	Males	Females	Total	Men	Women	Total	
1829	229	118	347	—	—	49	—	—	—	—	—	—	396
1831	197	130	327	—	—	65	—	—	—	—	—	—	392
1832	195	130	325	—	—	79	—	—	—	—	—	—	404
1833	191	128	319	—	—	86	—	—	—	—	—	—	405
1834	182	119	301	—	—	96	—	—	—	—	—	—	397
,,	8	3	11	2	—	2	*Received their freedom*						13
1835	177	117	294	—	—	106	—	—	—	—	—	—	400
1836	177	116	293	—	—	113	—	—	—	—	—	—	406
1837	174	116	290	62	53	115	—	—	—	—	—	—	405
1838	174	116	290	64	59	123	—	—	—	—	—	—	413
1839	172	115	287	65	63	128	—	—	—	—	—	—	415
1840	167	113	280	—	—	135	—	—	—	50	10	60	475
1848	133	97	230	—	—	146	—	—	9	—	—	—	385
1849	129	94	223	78	70	148	4	8	12	—	—	—	383
,,	3	3	6	—	—	—	4	3	7	*Received their freedom....*			13

(*b*). Much to their own satisfaction—the black population occupied *(the Quintál)* a separate village; situate on an eminence south of the high road from Saõ Joaõ to Caëthé, about midway between the European establishment and the mine.

The irregularly grouped cottages consist—like those of the Brazilian peasantry—of a wooden frame-work, wattled with *(cipós)* tough climbing plants and laths of *(taquára)* bamboo, thickly plastered with clay, and heavily thatched with *(capim sapé)* coarse reedy grass. Those inhabited by families contain several apartments; but childless couples and single people seldom cared to have more than one room; girls of marriageable age, however, slept—under care of a Brazilian matron—in quarters specially provided for them. As the old and scattered cottages fell into decay, rows of larger, higher, and more commodious tile-roofed houses were built in their stead; but the inhabitants,—objecting to be overlooked by their neighbours, and missing the snugness of their ancient huts,—generally disliked the change.

parts of its range from east to west, between Cocaës

In the mornings and evenings those who were fond of gardening cultivated little plots of bananas, mandiocca, sweet-potatoes, sugar-cane, red pepper, cabbages, and other vegetables; whilst the more industrious and respectable people also planted small *(rossas)* paddocks of Indian corn, *(feijaõ)* beans, and pumpkins. These they either sold, amongst themselves, to the European miners, and to the Company; or used, with their surplus food, for fattening the pigs and poultry which they kept in great numbers and sold at high prices.

From 1844 to 1849 the *Quintál* was periodically inspected, and prizes were awarded to owners of the cleanest houses, best kept gardens, and finest pigs. The sums—ranging from (one *pataca)* about nine pence to (two *milreis)* four shillings and sixpence each—it is true, were but small; yet they excited much emulation, and were received with exceeding pleasure.

Water for washing and for irrigation flowed through the village from a neighbouring pond, in which the men and boys used frequently to swim; but a beautiful spring, near the *mine-gate*, supplied drinking-water, and filled the children's baths.

(*c*) The following abstracts of accounts kept at the mine show as well the kinds of clothing, as the longest, shortest, and average intervals at which similar articles were issued.

Men.

Articles.	Intervals (months); Longest.	Shortest.	Average.
Cloth jackets....	35·	17·	26·
,, trousers ..	23·	14·	20·
Flannel shirts ..	23·	10·	15·
Duck shirts	70·	17·	40·
,, trousers ..	70·	14.	45·
Cotton shirts....	8·	3·	5·4
,, trousers ..	8·	3·	5·4
,, jackets (Mine)	70·	35·	52·
,, trousers ,,	35·	23·	27·
,, shirts ,,	70·	23·	39·
Caps, woollen ..	23·	17·	22·
Hats, leather ...	70·	17·	52·
Capes, varnished cloth	70·	17·	47·
Coverlids	65·	17·	37·

Women.

Articles.	Intervals (months); Longest.	Shortest.	Average.
Printed-cotton dresses....	12·	9·	11·
,, handkerchiefs	12·	7·	10·
Cloth dresses ..	45·	24·	33·
,, petticoats.	19.	13·	17·
,, wrappers .	48·	34·	43·5
Flannel shifts ..	46·	9·3	26·6
Cotton ,, ..	7·5	4·7	6·3
,, skirts ..	8·	3·5	6·
Hats..........	—	—	24·
Capes, varnished cloth........	102·	90·	95·
Coverlids......	24·	12·	20·

All linen and woollen goods were imported direct from England; but everything else was of Brazilian manufacture.

The orderly and neatly-dressed people made their clothing last much longer than the dissolute and careless, who were sometimes in rags.

and Tijuco, rises from five to eight hundred feet above

(*d.*) Accounts carefully kept during long periods show the *Rations* of each individual to have averaged,—

Fresh beef	2·88 lbs.	*(Avoirdupois)*	per week;	
Bacon *(toucinho)*	0·51	,,	,,	,, ;
Indian corn flour *(fubá)*	6·95	,,	,,	,, ;
Beans *(feijaõ)*	3·79	,,	,,	,, ;
Prepared mandiocca flour *(farinha)*, on Sundays	0·40	,,	,,	,, ;
Coffee (sweetened with *rapadura)*	1·50 pint per day;			
Rum *(restillo)* per man..............	0·50 gill	,, ;		

The beef was boiled with greens and red pepper, to which rice was occasionally added;—the beans and bacon were dressed together; and the Indian-corn flour was made into hasty-pudding *(angoú)*; prepared mandiocca flour—though sometimes eaten alone—is generally mixed with beans and bacon.

On Sundays some of the women also received a glass of spirits each; but many people of both sexes abstained from intoxicating drink; receiving instead, perhaps rather more than, its value in money.

Each person received 0·45 lb. *(Avoirdupois)* of soap per week; and small quantities of tobacco were occasionally distributed to those who smoked.

(*e.*) Beside lodging, raiment, and food, every one received wages; which—regulated as well by the occupation, as by the skill and industry of the labourer,

ranged amongst women,	from 2*d.*	to 1*s.* 1½*d.*	and averaged 4*d.*	per week each.
	,, (80 *reis*)	,, (500 *reis*)....	,, (160 *reis*)	
,, ,, men,	,, 3½*d.*	,, 2*s.* 3½*d.*	,, 10*d.*	,,
	,, (140 *reis*)	,, (1,020 *reis*) ..	,, (372 *reis*)	

Infants received a half-penny, and children of two or three years a penny a piece, which was, of course, spent in fruit and sweets.

On account of their exemplary conduct thirty-eight men and twenty-two women received their rations uncooked and their wages in money; all the others were paid in *tokens*, current only amongst themselves and at a *(venda)* shop in the village; but people of good character frequently exchanged their *tokens* for cash at the office.

The village shopkeeper furnished, weekly, a list of his retail prices; which were always compared with, and sometimes checked by, current wholesale rates. Now and then, however his supplies were insufficient, and sometimes their quality was inferior; on such occasions the people—never slow to complain—had recourse to other shops in the neighbourbood. Except that no one was allowed to buy more than half a gill of wine or spirits per day, the slaves enjoyed uncontrolled disposal of their wages. The shopkeeper's accounts showed how they were expended; viz.—

on Groceries......................	0·710
Fruit and Vegetables............	0·040
Wine and Spirits	0·146
Drapery	0·105
	1·000

the adjoining country. On the north rough declivities

As well to encourage habits of economy as to protect the prudent from being plundered, as sometimes they were, the Association permitted a *Savings Bank* to be established; where all investments bore interest at the rate of five per cent., and were repaid on demand. The depositors slowly but regularly increasing—numbered at last about a score; and their individual savings ranged, from a few shillings, to more than five pounds. On retirement of the promoter, however, the people—fearing that a knowledge of their circumstances might lead his successor, a stranger, to curtail their little privileges—withdrew their money.

(*f.*) As the men had been trained to work underground many were handy with the shovel; but—inasmuch as skilled labour was, for the most part, performed by Europeans—the slaves were neither apt at using the *pick*, nor expert at *(timbering)* propping and securing the shafts and drifts of the mine. Several, however, were more useful as charcoal-burners, car-drivers, and muleteers, than as miners; and many, taught by English artisans—became clever masons, smiths, and carpenters.

Of the boys a few were brought up as miners; several worked on the farm and in the stables; many—eager for instruction—were skilful artificers; and one—an assistant in the hospital for several years—frequently operated, and administered simples, with great success.

The women filled and drove the ore-carts, assisted at the *Stamps*, reaped grass, washed, and cooked, by turns. A few, of the handiest and most trustworthy, cleaned the gold. Those who had unweaned children were employed on sheltered work, which suffered no prejudice from occasional interruption.

The older girls worked, generally, with the women; whilst the younger—superintended by a Brazilian matron—cleaned, spun, and wove cotton, and made and mended the clothing. The children either watched and assisted the girls at their labour, or amused themselves in an adjoining playground.

The aged and feeble of both sexes cultivated a spacious garden, whence the public kitchen was supplied; whilst a few, altogether past work, either waited on the cooks, or betook themselves to the hospital.

Freemen and slaves, whatever their occupations, had the same periods of labour; viz.—

Miners	8	hours	per day;
Stamps-men and *whim*-drivers	12	,,	,,
Artificers, women, and all others at the surface, from 7 a.m. to 5 p.m. except on Saturdays, when they left work at 2 p.m.	10	,,	,, ,

For breakfast and dinner intervals of half an hour each were allowed.

In the evenings young people danced in the open air to their own songs; their elders either looked on and smoked, attended to their household duties, or worked in their *(rossas)* fields and gardens; but at eight o'clock the village *(venda)* shop was shut, and a bell summoned all to their homes.

(*g.*) As so many of the people had grown up before they were kidnapped in Africa, and the rest were their children, it is scarcely surprising that the laws and usages which regulate civilized life were frequently transgressed. The

alternate with steep escarpments; but towards the

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offences, of course, differed in degree; but, unfortunately, some required chastisement. This, however, was never inflicted until guilt had been clearly proved, not only by confronting the accused with his accuser, but by the testimony of other persons, summoned on both sides, who were examined before the Chief Commissioner, one—at least—of his clerks, and a Brazilian *(Juiz de Paz)* magistrate.

A record of convictions from 1836 to 1843, shows the annual average to have been.—

	Men.	*Women.*
Attempts to murder	0·2	—
Fire-raising	0·3	0·1
Housebreaking	0·5	0·1
Theft	15·5	2·7
Drunkenness	35·0	10·3
Rioting	5·0	4·0
Adultery	8·1	9·4*a*
Assaults	10·0	5·3
Disobedience, and neglect of labour	17·0	5·0
Sundry smaller offences	20·0	18·0
	111·6*b*	54·9*b*
	166·5	

Attempts to murder, fire-raising, and house-breaking, were generally punished by flogging;—theft, drunkenness, rioting, and adultery, by ferula;—assaults, pilfering, and neglect of labour, by imprisonment; and smaller offences, by trifling fines: aggravating and extenuating circumstances, however, were always taken into account.

The punishments inflicted, during the same period, averaged annually—

	Flogging.	*Ferula.*	*Imprisonments.*	*Fines*	*Totals.*
Men	1·	41·	43·	36·	121·*b*
Women	—	31·	24·	8·	63·*b*
	1·	72·	67·	44·	184·*b*

The floggings	ranged from	10 to 36 lashes;
,, ferula	,,	2 ,, 12 blows;
,, imprisonments	,,	1 ,, 7 nights;
but for aggravated crimes ..	,,	7 ,, 28 ,, ;
,, fines	,,	a penny to nine pence. (40 *reis*) ,, (320 *reis*)

The surgeon was present at floggings only; the Magistrate and the Commissioner witnessed every punishment.

The first two or three months after a flogging passed almost without crime; by degrees, however, offences became greater and more frequent; until—in perhaps twelve or eighteen months—some enormity compelled an unwilling recourse to the lash.

a With Europeans and Brazilians, as well as with their own countrymen.
b Fine and imprisonment were sometimes inflicted for the same crime.

south gentle slopes, deeply scored by narrow glens,

The following columns—compiled from accounts already mentioned—show that the people, generally, transgressed but seldom; whilst the repeated offences of a few hardened delinquents made up the mass of crime.

Persons punished.	Proportion of the entire population: *Men.*	*Women.*
More than thirteen times each	0·038	0·003
,, six ,, , but less than thirteen	0·088	0·046
,, three ,, , ,, six	0·166	0·062
Thrice	0·093	0·027
Twice	0·060	0·101
Once	0·081	0·096
	0·526	0·335
Persons never punished	0·062	0·077
	0·588	0·412
	1·	

(*h.*) Two or three hundred yards east of the village a spacious hospital—bounded on three sides by an airy court-yard, and on the fourth by a beautiful garden—afforded, in several large and well-ventilated wards, separate, though similar, accommodation for patients of all classes.

The English surgeon, who superintended it, was aided in his professional labours by an experienced, keen-witted, creole (*f*); and in housekeeping, by a resident Brazilian matron, to whom, also, the cooks, nurses, and other attendants were subject.

Servants of the Company, in any stage of disease, were received during the day; but those only who needed immediate treatment were admitted at night.

The in-patients, — who ranged from eight to nineteen and averaged above fifteen,—were allowed 4·45 lbs. of fresh meat per week each, beside the ordinary rations of meal, bacon, beans, mandiocca flour, rice, and coffee (*d*); but, at the Surgeon's discretion, fowls, eggs, bread, butter, tea, milk, arrowroot, wine, &c., were partially, or altogether, substituted.

(*i.*) At an early period of the Company's existence a church was built, and a paid, resident, chaplain was appointed.

On ordinary week-days Mass was rather slightly attended; but on Sundays and high festivals crowded congregations of slaves, indiscriminately mixed with free labourers, and the families of neighbouring farmers, not only filled the consecrated place, but knelt, outside it, on the ground. Habitually, also, many confessed during Lent, and received the Holy Eucharist at Easter.

(*j.*) In 1846 the chaplain, who was also the village schoolmaster, readily undertook to teach the children of the Company's people; and great pleasure, but no surprise, was felt, throughout the establishment, at finding their proficiency, in reading, writing, and arithmetic, fully equalled that of their free schoolfellows.

impress the scenery with a character singularly diversified and romantic.

Great part of this tract is covered with an evergreen forest, which, in season, glows with purple blossoms; and a luxuriant undergrowth is intertwined with climbing plants, of many kinds, which also bear flowers of rare beauty.

Immediately south of the *Serra* broad undulating pastures *(campos)* extend to the river of Socorro.

The *flora* and *fauna* of *Gongo Soco* and its dependencies are very rich; but to them our enquiry does not extend.

About half-a-mile east of the mine, several pleasant villas and many neat cottages – inhabited by the English officers and workmen – were irregularly clustered round a picturesque little church; the spire of which—rising above a grove of palms and other evergreens—is still a

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To an experiment of so novel, and—as they thought—so questionable a character, many native slave-owners offered violent opposition: not that they objected to intercourse between young people of different conditions, for this prevailed everywhere; but because they believed education incompatible with slavery. It was soon evident, however, that instruction had not unfitted the people for labour, and that the aptest scholars were often the best and most orderly workmen.

But in less than four years every measure which experience had devised (Lyon, Skerrett, Duval, Morgan, Crickitt, & Henwood, *Reports of the Imperial Brazilian Mining Association*, VIII. p. 15; XV. p. 8; XVII. pp. 17, 42; XXII. p. 23; XXV. p. 18; XXVIII. p. 19; XXX. pp. 39, 107—110; XXXIII. p. 2; XXXVIII. p. 5; XL. p. 13; XLI. p. 11; XLIII. p. 8; XLV. p. 13.), for improving the physical and moral condition of the slaves, was abolished without enquiry or scruple by parties newly employed to superintend the mines.

In 1857 the estates and people were sold.

This account of the manner in which slaves were treated at *Gongo Soco*, is not offered as an apology for slavery.

characteristic object in the landscape.* The pretty pleasure-grounds and trim gardens,—wherein fruit-trees were interspersed with flowering shrubs, and European with tropical vegetables,—the busy shop, the well-attended school, and—above all—the clean, well dressed, and respectable population; gave the beautiful little village an air of life, order, and comfort, of which the Province afforded no other example.*

(VI.) (*a.*) The soft talcose iron-slate already described,† is succeeded by a foliated rock, which—conforming to the strata beneath‡—dips towards the south.

The lower portions—composed chiefly of reddish-brown talc largely mixed with granular quartz—are, at intervals, conformably interlaid by short, thin, lenticular masses of iron-glance and hydrous iron-ore,§ which have been carefully examined, but without success.

In the upper and more quartzose part of the series, a broad band of crystalline magnesian limestone‖

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* "The situation of *Gongo Soco* adds much to its beauty, being a narrow valley, "bounded on the north by the high wooded Serra, that runs westward from "Cocaës, and by a lower undulating grassy elevation on the south; with the "exception of the large house occupied by the Chief Commissioner, the others "—in which the officers, and European miners reside—are all of one story, "arranged in streets, isolated, and in the English cottage style, adorned in front "with flower-beds, and not unfrequently with palms and other tropical trees. "Near the centre of the village, stands a small but elegant church, for the use "of the Brazilian workmen and slaves, employed by the Company."

Gardner, *Travels in Brazil*, p. 491.

† *Ante*, p. 257. ‡ *Ibid*, pp. 178, 183, 248, 259.

§ Tregoning, Harris, Collins, Bray, Blamey, and Pengilly, *Reports of the Imperial Brazilian Mining Association*, xx. p. 71; xxi. pp. 78, 93; xxii. pp. 114, 118; xxiv. pp. 53, 56; xxv. p. 69.

‖ "Very variable quantities of the accompanying rock are interposed amongst

(Dolomite),—the only one of the kind recognised within many miles.—is largely quarried and burnt for use.

(*b*.) Alternate layers of iron-glance and of quartz *(Itabirite)* form great part of the *Serra da Piedade* * near Caëthé, and in some measure conform to its contour; but here and there the ore occurs in small lenticular beds, which—when mixed with earthy manganese and talc—sometimes afford traces of gold.†

At *Descoberta* the iron-formation is overlaid by talcose clay-slate; thick-lamellar, soft, and of brick-red mottled with white in some places; but fissile, hard, and pale buff coloured in others. Its laminæ,—like those of the rock beneath,—exhibit occasional contortions; but range, on an average, 10°–20° E. of N.—W. of S., and dip 60°–70° E. The principal joints sometimes bear a few degrees E. of N. and W. of S.; but, on the whole, they are nearly meridional.

At short but unequal intervals, reniform and lenticular masses of granular quartz either interlaminate the

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"the calcareous portions * * * A specimen free from admixture contained

"Carbonate of lime	29·7	per cent.
"Carbonate of magnesia..........	35·6	"
"Silica	0·5	"
"Alumina	0·2	"
"Protoxide of iron	3·2	"
	99·2."	

Faraday, *Reports of the Imperial Brazilian Mining Association*, v. pp. 90, 92.

* "Dans la *Serra da Piedade* * * * la masse d'itabirite est puissante de plus "de 1,000 pieds."—von Eschwege, *Annales des Mines*, viii. p. 419.

von Spix und von Martius, *Reise in Brasilien*, i. p. 396; ii. pp. 422, 456. de Saint Hilaire, *Voyage dans l'Intérieur du Brésil*, i. p. 137. Gardner, *Travels in Brazil*, pp. 500—502. *Ante*, p. 169.

† Henwood, *Cornwall Geol. Trans.*, vi. p. 294.

slate, or conform to its joints; but—unlike the larger bodies at *Morro Velho* * — no single mass interlies both. The shallower layers and vein-like *bunches* sometimes touch at their edges; but even at a depth of twelve fathoms, both their sizes and numbers have already diminished. Few of them, however, exceed a fathom in length, or six inches in width; and generally, they are much smaller. The quartz is milk-white in the harder and paler slates; but it is deeply tinged with earthy brown iron-ore in the softer and darker-coloured strata.†

Although no member of the talcose series is absolutely barren, the white quartz and the *(Country)* schistose rocks afford mere traces of gold; many small beds of *(gossan)* quartz and earthy iron-ore, however, are very rich.†

Notwithstanding a slight admixture of tellurium, the gold is of excellent quality.†

Sub-angular blocks of iron-glance, cemented by earthy brown iron-ore (*Canga*‡), overlie the talcose formation.

Operations are carried on in the same rude and thriftless way as at *Itabira* § and *Pitangui*; ‖ but the mine is wrought only at intervals, when the proprietor —a wealthy land-owner— has no field-work for his slaves.

(*c.*) The iron-formation, which—ranging some 10°

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* *Ante*, pp. 187, 206, 207, *Table VI.*

† Henwood, *Cornwall Geol. Trans.*, VI. p. 295.

‡ *Ante*, pp. 216, 236, 247, 248. § *Ibid*, p. 218. ‖ *Ibid*, p. 224.

W. of N.—E. of S., and dipping 40°–65° E.,*—has long been extensively wrought between *Boa Vista* and *Duraõ* † in the lower slopes of the Caraça, is succeeded by rocks of which quartz and talc are chief ingredients. Amongst these, coarse-grained reddish-brown and pale buff coloured quartzose talc-slates–scarcely distinguishable from the auriferous beds wrought in a lower part of the series at *Santa Rita* ‡—are largely developed. Bands of fine-grained greyish-white quartz-rock, often thinly sprinkled with talc, interlie the talc-slate at unequal intervals; but, after comparatively short courses, they gradually become thinner, and ultimately disappear. Higher portions of the talc-slate series, however, alternate with broad, slightly foliated beds, composed in great measure of indurated talc, mixed generally with red and brown earthy iron-ore, and less frequently with granular quartz. Near Cattas Altas some of these—mottled with pearl-white talc—afford a few small crystals of topaz.§

Particles and granules of gold are scattered through all the softer strata; but seldom in quantities sufficient to pay for extraction.‖

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* *Ante*, pp. 221—241.

† In 1814, the mines of this range—wrought by
165 freemen, and
288 slaves,
yielded 16,660·25 *oitavas* (= 160·04 lbs. Troy) of gold.—von Eschwege, *Pluto Brasiliensis*. Tabellarische Uebersicht aller Goldlavras jeden Districts in der Provinz Minas Geraes, iv.

‡ *Ante*, p. 176.

§ Near the village of Catas Altas "there are slips in some of the mountain-"sides in which topazes are found, but rarely any of good quality."
Mawe, *Travels in Brazil*, p. 289.

‖ The whole vicinity is irrigated by numerous rivulets, many of which are

These talc-slates, with their subordinate bands of quartz-rock and ferruginous talc, not only mantle the lower eastern slopes of the Caraça, but stretch far into the *(Campos)* open country, from Brumadinho to Cattas Altas, and thence beyond Camargos.

(*d.*) At *Fraga*, near Bento Rodriguez, grains of quartz, nests of pearl-white talc, crystals of oxydulated iron, and particles of gold, are irregularly disseminated through a breadth of many fathoms in several adjoining beds composed chiefly of indurated talc, deeply coloured with red and brown earthy iron-ore; which have been occasionally wrought for many years,* but with little success.†

These somewhat imperfectly lamellar talcose rocks—maintaining a tolerable parallelism to the neighbouring mountain, and ranging from south-east to north-west, —enclose a bed of different character, which interlies them for some distance; on meeting one of their principal joints, however, it takes a meridional direction; but on entering the quartzose talc-slate (*Itacolumite*), it dwindles from several feet to a few inches in width, and at last dies away. Quartz, either colour-

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" diverted from their courses to a great distance for the purposes of gold-washing. " In all parts, even on the tops and sides of the hills, we observed operations of " this kind going on."—Mawe, *Travels in Brazil*, p. 289.

* In 1814 thirty-six slaves extracted 1684 *oitavas* (=16·176 Troy lbs.) of gold. von Eschwege, *Pluto Brasiliensis*, Tabellarische Uebersicht aller Goldlavras jeden Districts in der Provinz Minas Geraes, v.

† The proprietor, like many other Brazilian mine-owners, neither clothed his slaves well, nor paid them wages; but unwisely allowed them instead, the uncontrolled disposal of all gold they obtained from appointed spots, by voluntary labour on Saints'-days.

less, milk-white, or deeply tinged with earthy brown iron-ore, is the chief ingredient; but pearl-white talc is also abundant; and flakes of iron-glance, as well as crystals of oxydulated iron, are irregularly scattered through the entire body. Small quantities of the *(gossan)* darker-coloured quartz are, at wide intervals, richly impregnated; and drusy cavities *(vughs)* in the other varieties are sometimes spangled with octahedral crystals of gold.

The mine was wrought to a depth of twenty-one fathoms, but it yielded no profit.

(*e.*) At *Thesoureiro*, between Marianna and Camargos, a broad band of imperfectly lamellar slate ranging 10°–20° W. of N. and E. of S., dips 50°–60° S., consists mostly of brick-red talc sparingly mottled with earthy white felspar, and differs from the adjoining rocks only inasmuch as it contains many small beds of colourless, smoky, milk-white, and brown quartz. Some of these interlie the laminæ, others the joints,‡ and many are oblique to both. None exceed a few feet in length, by an inch or two in breadth; and generally they are even smaller. No part of the formation is, perhaps, absolutely barren; but its talcose ingredients, as well as the beds of colourless and smoky crystalline quartz they enclose, are comparatively poor; the white and brown quartz—one flecked with oxydulated iron, the other mixed with much earthy brown iron-ore—afford many small but rich *bunches*; so irregularly distributed, however, that the same work-

‡ *Ante*, pp. 299, 301.

people who extracted	17·695 lbs. (*Troy.*)	of gold,	in the last six months of 1842,	
obtained	0·461 „	„	only in the first six months of 1843; *	

even then drusy crevices in their least productive parts were sometimes thinly studded with little crystals of gold.

(*f.*) At *Antonio Pereira* the iron formation † is overlaid by a series of conformable beds several hundred fathoms in thickness; which,—ranging about south-east and north-west,—dipping 10°–45° north-east,—and by turns of massive, fissile, or thick lamellar structure,—consist, in great measure, of red or brown earthy iron-ore and aluminous clay, largely mixed and often interlaminated, however, with whitish talc, and —less frequently—with earthy black manganese, iron-glance, and quartz.

Although the entire series is more or less auriferous, certain unpromising beds have been but slightly examined; both above and below them, however, other strata were, for some time, largely wrought ‡ at *Matta Cavallos,* § *Tacoara Queimada, Macacos,* || *Matta*

* Colonel Fernando Luiz Machado de Magalhães, MSS.

† *Ante*, p. 213.

‡ Da Gama, Edwards, Gardner, Tregoning, & Martyn, *Reports of the Imperial Brazilian Mining Association*, I, pp. 49-64.

§ Late in the last century a *bunch*, from which (1,800 oitavas) 17·29 *Troy* lbs. of gold were extracted in two hours, was discovered about (100 palmos) 12 fms. below the surface at *Matta Cavallos.* The workmen, however,—too eager in pursuit of their prize—unhappily neglected the sides of the shaft; which, suddenly collapsing, crushed an overseer *(feitor)* and ten slaves, whose remains still lie buried in the ore.—Da Gama, *Ibid*, I. pp. 49-51. Gardner, *Ibid*, I. p. 56. von Spix und von Martius, *Reise in Brasilien*, I. p. 401. Walsh, *Notices of Brazil*, II. p. 210.

|| "At the *lavra Macacos* we have sunk and *driven* in different places about "thirty-six fathoms, but finding that as we sunk, the formation instead of im-"proving became worse, and its appearances more unfavourable, we after some

Matta, and *Rumaõ*,* in different parts of their range; some of these afforded rich *bunches*,† others were thinly sprinkled with gold;* but all have been long since abandoned.

The auriferous beds of ferruginous talc-slate are succeeded by calcareo-siliceous rocks;‡ which, immediately above the *(lavra)* works of *Matta Cavallos*, form a cliff, perhaps one hundred and fifty feet high. This deposit consists generally of coarsely-foliated brownish-grey quartz-rocks, which enclose small lumps and thin veins of milk-white quartz; sometimes, however, lime is an ingredient in the mass, and then the included portions are of calc-spar. Particles and minute flakes of gold are thinly disseminated through the white quartz; but are found in no other part of the formation.

The calcareo-siliceous rocks are overlaid by a few thin, fissile beds of pale blue slate.

"consultation were of opinion that it would be a waste of time and money to "proceed any further," * * * .

"At the *lavra Rumaõ* we have, by aid of a hand-pump, sunk a shaft $6\frac{1}{2}$ fathoms; "and have *driven* north-west about 10 fathoms: different parts of the formation "show gold, but it would in no way meet the expenses, and as we could see "nothing to warrant further operations, we were unwilling that any more money "should be wasted so we accordingly shut it up," * * * .

"There are several formations in the estate, and each of them when washed "will show a little gold, but after having examined them very minutely, and "proved them in several places by sinking and *driving* where we thought there "appeared any chance of success, we feel no hesitation in saying we believe "they will never pay the expenses of an English Company."—Trebilcock & Jennings, *Reports of the Imperial Brazilian Mining Association*, vii. pp. 95, 96.

* *Ante*, p. 303, Note ‖. † *Ibid*, Note §.

‡ "At Antonio Pereira we found primitive limestone, and * * * dolomite, "both granular and lamellar, in great abundance." Caldcleugh, *Travels in South America*, ii. p. 263. von Spix und von Martius, *Reise in Brasilien*, i. p. 402. von Helmreichen, MSS.

(*g*.) At Capaõ* near Ouro Preto pale-blue talcose

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* "At the topaz-mine near Capaõ * * * the argillaceous schistus, which "formed the upper stratum, appeared in a variety of stages, the greater part "migrating into micaceous schistus. In one part I observed two negroes poking "in the little soft veins, which the slips" of rock "disclosed, with a piece of "rusty iron, probably part of an old hoop; and on enquiring what they were "about, I was informed they were the *miners*, searching for topazes. I took "one of their instruments, and on using it as they did, found these veins to "contain a very minute micaceous substance approaching to earthy talc, also "some quartz, and large crystals of specular iron ore. I had the good fortune "to find two or three topazes, which, as they had only one pyramid each, and "appeared fractured, I judged to be out of their original place. * * * I fully "expected to meet with some having double pyramids, but to my great disap-"pointment, all that I found were entirely detached. From a great quantity "(at least a cart-load) of inferior topazes, * * * I could not select one with a "double pyramid. They informed me that sometimes, but very rarely, topazes "had been found attached to quartz, but even in these instances the quartz was "fractured and out of its original place. The topazes which were shewn to me, "were very imperfect, and full of flaws. They also informed me that green "topazes were sometimes found, which I very much doubted. If any substance "of that colour, resembling topaz, did occur, it was most propably *Euclase*."

MAWE, *Travels in the interior of Brazil*, pp. 233-4.

"The Euclase, which is still of such rare occurrence, is met with in streams "in the immediate neighbourhood of this topaz work; but never either attached "to or embedded in the quartz."

CALDCLEUGH, *Travels in South America*, II. p. 232.

"Von dem *Morro de Gravier* steight man nur wenig abwärts, um zu der schö-"nen *Fazenda Capaõ* und der eine Viertelstunde weiter entfernten *Fazenda Lana* "zu kommen. Diese Gegend ist die Fundgrube der bekannten brasilianischen "gelben Topase. Die Grundlage des Gebirges ist auch hier der Gelenkquarz, "jedoch steht derselbe selten in seiner gewöhnlichsten Form, dagegen öfter in "der, von ESCHWEGE Eisenglimmerschiefer genannten. Abänderung zu Tage "an. Auf ihm liegen mächtige Lager eines modificirten Glimmers, den man "auch erdigen Talk nennen könnte. * * * Unmittelbar hinter der *Faz. Lana* "ist ein Hügel auf der einen Seite, im Umkreise von mehr als zwei Tagwerken "un bis auf eine Höhe von sechzig Fuss, durch Regen und künstlich herab-"geführte Wässer so aufgeweicht, dass er einem Breie gleicht, und sich, ohne "sich im Einzelnen zu verschieben, immer tiefer herabsenkt. * * * Das "Erdreich wird mit Schaufeln in lange Haufen aufgeschüttet, und durch darü-"bergeleitetes Schlemmwasser in einen engen, mit einigen Holzgittern versehenen "Canal abgespült, so dass nur die festeren Theile zurückbleiben, welche sodann "mit Hauen und den Händen durchwuhlt, und nach Topasen durchsucht werden. "Diese härteren Bestandtheile der aufgelösten Formation sind die Trümmer "eines oft ganz bröcklichen weissen Quarzes, bisweilen mit losen Bergkrystallen "durchmengt, und werden oft von einer weissen oder braunen eisenschüssigen "Porzellanerde begleitet. Letztere, welche hier *Massa branca* nennt, ist das

clay-slates bound the opposite sides and conformably

" sicherste Zeichen von dem Vorkommen der Topaze, die sowohl zwischen hir " als, jedoch seltener, zwischen dem zertrümmerten und aufgelösten Quarze lose " und zerstreut liegen. Den fein aufgeweichten Glimmer von gelblich-und " tomback-brauner Farbe, den man erdigen Talk zu nennen versucht ist, bezeich- " nen die Arbeiter mit dem Namen der *Malacacheta.* In ihm findet man die " Topaze ebenfalls, aber minder häufig als in jenen zertrümmerten Ueberresten " von Gängen, und zwar hat man sie nicht bloss in dem aufgeweichten Theile der " Formation, sondern, wie namentlich bei *Capaõ*, auch in dem noch festen " bemerkt. Gemeiniglich läuft der die Topasen enthaltende, mit Porzellanerde " ausgefüllte Quarzgang in einem Salbande von erdigem Talke, welcher sich von " dem nahe liegenden durch Farbe und Dichtigkeit unterscheidet, und *Formaçaõ* " genannt wird. Der Quarzgang, dessen Hauptrichtung wegen der Beweglich- " keit der ganzen Masse nicht immer ganz Dieselbe ist, bei unserer Gegenwart " aber von Mitternacht nach Mittag lief, hat eine Mächtigkeit von einem zoll " bis zu anderthalb Fuss und darüber, und wird von den Arbeitern sorgfältig " verfolgt. Nicht selten macht ergrosse nesterförmige Erweiterungen, welche " nichts als tauben, zertrümmerten Quarz ohne Topase darstellen. Die letzteren " werden äusserst selten noch im Zusammenhange mit dem Quarzgesteine oder " mit Bergkrystall gefunden; gewöhnlich sind sie auf der einen Seite abge- " brochen; solche mit krystallinischen Endflächen an beiden Seiten haben wir " selbst in der Grube nicht auffinden können. * * * Die Grösse der Steine ist " sehr verschieden; nach der Aussage der Arbeiter sind schon faustgrosse Stücke " gefunden worden. Die natürliche Farbe ist mannichfaltig, bald graulichbald " weingelb, dann eine Mittelfarbe aus Weingelb und Fleischroth von verschie- " denen Graden der Höhe, selten dunkelroth. Die jenigen Steine, welche in der " *Malacacheta* gefunden werden, sollen die hellsten seyn. * * * Die Zahl " der hier jährlich gefundenen Topase ist sehr beträchtlich, und dürste sich auf " fünfzig bis sechzig Arrobas" (2560 to 3972 lbs. *Troy*) " belaufen, jedoch ist " diese Summe nicht immer ganz rein und zur Verarbeitung geeignet, veilmehr " ist ein grosser Theil derselben von so unreiner Farbe und so voll Sprünge, " dass er von den Besitzern weggeworfen wird. Von der geringstein Sorte " der zum Schnitte-tauglichen Steine wird die Octave" (55·33 grains) " zu " dreihundert und zwanzig Reis" (about nine-pence), " von der besten zu zwei- " tausend Reis" (four shillings and sixpence) " verkauft. Aus gezeichnet grosse, " schöne, feurige Steine, zahlt man an Ort und Stelle mit zwanzig bis dreissig " Piastern. * * * Zugleich mit den Topasen kommt hier die Euklase (*Safira*) " vor, welche erst, seitdem Mineralogen Nachfrage nach ihr gethan haben, die " Aufmerksamkeit der Mineiros auf sich zieht. Im Allgemeinen ist diese " Steinart selten, und zwar kommt sie häufiger in der Mine von *Capaõ* als in der " von *Lana* vor."—von Spix und von Martius, *Reise in Brasilien*, i. pp. 327-9.

" Les couches talqueuses, liées au thonschiefer, offrent un champ plus riche " aux minéralogistes. * * * Au milieu de parties de ces roches réduites à " l'état d'argile, on trouve en nids et en petites veines, dans de la lithomarge, de " beaux cristaux jaunes de *topaze du Brésil*, de l'*euclase*, minéral si rare, du *fer* " *oligiste* en grandes tables hexagonales, accompagné de cristaux de mica. Des

interlie several parts of a broad band, which—ranging nearly E. and W., and dipping 20°–30° S.,—consists in great measure of earthy talc and brown iron-ore; mottled, however, with felspar-clay, and, less frequently, with iron-glance. Irregular masses and, either imperfect or double-pointed, crystals of quartz are, without apparent order, implanted throughout.

Crystals of topaz—imbedded singly—are peculiar to no part of the formation; but are most numerous where felspar abounds. Their positions are as unconformable with regard to one another as they are to the natural faces, and imperfectly lamellar structure, of the surrounding ingredients; and thus dissimilar matrices sometimes enclose different parts of the same crystals. They are of every hue between dark amber and pale yellow;—from half an inch to ten inches, though on an average from two to three inches, long;—and from one-eighth of an inch to three inches, but generally about half an inch, in thickness. Their opposite ends present, sometimes planes perpendicular to the axis of the prism, sometimes dissimilar pyramids; * more frequently, however, one extremity is plane and the other pyramidal. But, except as specimens, few are of much

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" cristaux de *quarz hyalin* avec des *topazes* implantées, ou réciproquement des " cristaux de quarz implantés dans ceux de topaze, et du *disthène*, rendent ce " gîte plus intéressant encore: les pays dapuis Villa Rica jusqu' à Capaõ, en " offrent les plus beaux exemples."—VON ESCHWEGE, *Annales des Mines*, VIII. p. 416; *Pluto Brasiliensis*, pp. 385–9.

Claussen, *Bulletins de l'Académie Royale des Sciences de Bruxelles*, VIII. 1re partie, p. 326. Daubrée, *Annales des Mines*, 4me Série, XIX. p. 704.

* Phillips, *Mineralogy*, 3rd Edition, p. 84. Mohs, *Mineralogy* (English translation by Haidinger), II. p. 31. Jameson, *Mineralogy* (Encyclopædia Britannica), p. 195.

value; for the greater number either are flawed,—enclose crystals of iron-pyrites, iron-glance, talc, and other substances,—or exhibit minute cavities, some seemingly empty, but others partly filled with pale yellow or orange-red liquid.* The flaws seem confined to no part; but the implanted minerals and the cavities occur on certain planes parallel to the axis of the including topaz. Open crevices in imperfectly formed crystals sometimes contain symetrically disposed octahedrons of oxydulated iron, their facets bearing frequent impress of substances which have disappeared.

The same formation yields also the euclase, but in much smaller numbers than the topaz,

Cross-veins of quartz, some two or three inches wide, range nearly north and south, but do not displace the strata they intersect.

An excavation, perhaps one hundred fathoms long, fifty wide, and from sixteen to twenty-five deep, has been made at Capaõ in pursuit of the topaz; but as a large stock of crystals has, for many years, remained unsold,† the works are seldom resumed, except to satisfy the enquiries of visitors.

At Boa Vista, in the same neighbourhood, a similar formation affords crystals of topaz in equal abundance; but there also operations have been discontinued.

(VII.) Great part of the district is overlaid with disintegrated matter; composed, mostly, of talc, quartz,

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* Brewster, *Edinburgh Journal of Science*, v. (1826), p. 126; *Edinburgh New Phil. Journal*, xxxviii. (1845) p. 386.

† A tolerable collection may be made, at the rate of a few pence per specimen.

and earthy red iron-ore: * in which search for gold is still made here and there, but with little success.

A.—*Directions of the auriferous deposits* extend to almost every part of the compass,

Rocks.	N. & S. to 30° W. of N.—E. of S.	30°—60° W. of N.—E. of S.	60° W. of N.—E. of S. to E. & W.	E. & W. to 30° N. of E.—S. of W.	30°—60° N. of E.—S. of W.	60° N. of E.—S. of W. to N. & S.	
Granite	—	—	—	—	—	—	—
Lower talcose and micaceous slates	1	1	—	1	1	—	4
Quartz-rocks	—	1	—	—	1	—	2
Clay-slates	—	1	2	3	1	—	7
Lower limestone	—	—	2	1	—	—	3
Iron-slates (*Jacotinga*)	4	4	—	6	2	3	19
Upper talcose and micaceous slates	1	2	—	—	—	1	4
Upper limestone	—	1	—	1	—	—	2
Totals	6	10	4	12	5	4	41
Proportions	·146	·245	·097	·293	·122	·097	1

but, like the *lodes* of Cornwall and Devon,† they have

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* Claussen *Bulletins de l'Académie Royale de Bruxelles*, VIII. 1re partie, p. 329.

† *Directions of veins, in Cornwall and Devon.*

	N. & S. to 30° W. of N.—E. of S.	30°—60° W. of N.—E. of S.	60° W. of N.—E. of S. to E. & W.	E. & W. to 30° N. of E.—S. of W.	30°—60° N. of E.—S. of W.	60° N. of E.—S. of W. to N. & S.	
Metalliferous veins (*lodes*)	·044	·136	·136	·500	·152	·032	·1
Cross-veins..	·498	·245	·049	·012	·061	·135	·1

HENWOOD, *Cornwall Geol. Trans.*, v, *Tables CIII. CVI.*

most frequently a nearly easterly and westerly range.

The foregoing details* show, however, that the auriferous deposits, as well as the rocks they interlie, maintain—whatever their mineral character—an exact parallelism with the chains of mountains in which respectively they occur.

B.—*Inclinations of the auriferous deposits*

where they interlie the planes of schistose structure	—varying from	10 to 70°	—average about	42°: †
„ conform to the joints................	— „	45 „ 80°	— „	65°. ‡

The highly inclined portions are not always rich, but the flatter parts are ever poor.§

C.—*Sizes or widths of the auriferous deposits.*

Except, perhaps, the upper limestone of *Gongo Soco* (VI. *a*),|| no considerable part of the series, above the granite of Caëthé and of the Caraça,¶ is absolutely barren; but the portions which either contain gold enough to be worth extraction, or offer promise to the miner,—though here and there several fathoms**—are generally from about two to eight feet wide; the

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* *Ante*, pp. 176—304; *Table X.* columns 2, 4, 11.

† "Throughout Cornwall, and the west of Devon, the mean dip of the *lodes* "may be about 70° from the horizon, but in this respect there is a considerable "difference between the *lodes* in the eastern and western districts."

Henwood, *Cornwall Geol. Trans.*, v. p. 247.

‡ "To whatever point the *cross-veins* may incline, their inclination from the "horizon is on the whole considerably greater than that of the *lodes*, and, on an "average, is probably little, if at all, less than 80°; although there are many "exceptions."—*Ibid*, p. 277.

§ Thomas, *Survey of the Mining district from Chacewater to Camborne*, p. 20. Henwood, *Cornwall Geol. Trans.*, v. p. 231; *Ante*, pp. 82—3.

|| *Ante*, p. 298.

¶ *Ante*, p. 174.

** *Ante*, pp. 189, 190, 255. *Tables VI. VIII. X.*

richest layers, however, seldom exceed six inches, and are often less than an inch.*

D.—*Relations of the auriferous deposits to the rocks which adjoin them.*

(1.) *Composition*—(*a.*) The only auriferous granite in Minas Geraës consists of a yellowish felspar, white quartz, and oxydulated iron-ore; † irregularly mixed, however, with crystalline granules of gold which—alloyed with from 0·05 to 0·08 its weight of palladium,‡ and sometimes enclosing, but more frequently imbedded in the other ingredients—thus forms an integral part of the rock.§

(*b.*) The talcose slates which—thinly sprinkled with particles of gold—rest on unproductive granite near Caëthé and in the Caraça,‖ as well as those which, in like manner, overlie the auriferous iron-ores in higher parts of the series,¶ enclose broad bands and short, thin layers of quartz; which generally conform to the foliation, seldom follow the joints, and are still less frequently oblique to both.** These are, at unequal distances, conformably interlaid by narrow beds and small lenticular masses of the neighbouring rocks.

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* *Ante*, pp. 230—2, 262—4, 266—7, 269, *Tables VIII. X.*

† *Ante*, p. 175. ‡ *Ante*, p. 176.

§ Berger, *Geol. Trans.*, I. p. 120. De Luc, *Geological Travels*, III. p. 342, Herbert, *Asiatic Researches*, I. p. 236. Sedgwick, *Phil. Mag. & Annals*, IX. (1831) p. 283. Henwood, *Cornwall Geol. Trans.*, V. pp. 15, 53, 73, 119, 235. Murchison, *Geology of Russia in Europe*, I. p. 483. *Ante*, pp. 46, 175.

‖ *Ante*, pp. 177—8.

¶ *Ante*, pp. 178—80, 298—302.

** Henwood, *Cornwall Geol. Trans.*, VI. p. 295; *Ante*, p. 180.

The quartz is mostly of a whitish hue; but portions are tinged with *(gossan)* earthy brown iron-ore, of which—near the surface especially—small *bunches* are numerous.

(*c.*) Where the talcose slates pass by degrees into clay-slates,* the conformable beds of quartz sometimes contain masses of iron-pyrites.†

(*d.*) The clay-slates also alternate with bands composed mostly of quartz, which is generally whitish, but here and there is either colourless or of smoky hue. The shallower parts of the pale-coloured varieties frequently enclose nests of earthy brown iron-ore, as well as *(vughs)* drusy cavities lined with crystals of quartz, or encrusted with spathose iron and arragonite.‡ At greater depths iron-pyrites prevails; mixed, however, with much smaller quantities of both arsenical and copper pyrites.§ Masses of slate, from a fraction of an inch to several fathoms in dimensions, occur without number in every auriferous bed; || but, perhaps, more

* "L'itacolumite alterne en bancs puissans et sur une grande eténdue avec le "thonschiefer."—von Eschwege, *Annales des Mines*, viii. p. 401.

Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. (1re partie) p. 325.

† *Ante*, pp. 180, 184. ‡ *Ante*, p. 196, *Table VI.* columns 8, 10.

§ *Ante*, pp. 194-5; *Table VI.* columns 8, 10.

|| At *Morro Velho* the proportions—of quartzose and slaty matter separated from the ore brought to the surface,—and of gold extracted from the ore stamped,—have been

Depths. fms.		Proportions of Rubbish rejected from *ore stamped.*		Gold extracted.
Surface to 50·0	....	0·131	....	0·0000159
50·0 — 100·0	....	0·035	....	0·0000142
100·0 — 142·8	....	0·045	....	0·0000138
142·8 — 162·6	....	0·246	....	0·0000268

Ante, pp. 202-3; *Table VII.* columns 8, 9, 25. *Reports of the Saint John d'el Rey Company*, xxxii. p. 60; xxxiii. p. 49; xxxiv. p. 48.

frequently in the quartzose than in the pyritous parts. Their characters are, generally speaking, identical with those of the adjacent strata; but frequently they are more or less transfused with one other ingredient of the surrounding matrix.

From the slate to the quartz the passage is often abrupt and immediate; as often, however, the transition is by shades barely discernible.* Frequently also the slate, for some distance from the body of quartz, is slightly impregnated with auriferous pyrites.†

(*e.*) The iron-formation comprises two groups;—the *Itabirite* and the *Jacotinga.*

(a.) The *Itabirite* consists, for the most part, of granular quartz, and of iron-glance irregularly mixed with oxydulated iron, earthy brown iron-ore, and hydrous oxide of iron, in alternating beds, sometimes separated by laminæ of talc; ‡ but seldom more than a few inches, and often less than an inch, thick. In this part of the series gold is rarely found. At *Cocaës* and *Gongo Soco,* however, one of the quartzose strata attains a width of several feet, is largely though irregularly charged with calcareous matter, flecked with iron-glance and talc, and thinly sprinkled with gold.§

(b.) The *Jacotinga* is composed in great measure of iron-glance,|| mixed generally with small quantities

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* Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, & Dublin Phil. Mag.*, XXV. p. 342; *Ante*, p. 194.

† Treloar, *Reports of the Saint John d'el Rey Company*, XX. p. 13; *Ante*, pp 186, 196, Notes.

‡ *Ante*, pp. 211, 214, 219, 221, 324–5, 248.

§ *Ante*, pp. 245, 249.

|| *Ante*, pp. 214, 219, 223, 225, 237, 243, 245, 247, 254; *Table VIII.* columns 3, 6, 9, 12, 15, 18, 21.

of earthy manganese,* and frequently with minute proportions of oxydulated iron,† earthy (brown and black) iron-ore,‡ titaniferous iron-ore,§ or the hydrous oxide of iron ‖ also; but seldom with all these at once. Talc, either foliated or massive, forms—especially in upper parts of the group—isolated masses and thin layers; ¶ but quartz is a rare, and an unwelcome, ingredient.**

Conformable beds, of which the poorer parts are barely discernible, and the richer are only a few inches wide, contain most of the gold in this formation.†† The neighbouring strata—partaking the changes they undergo in various parts of their range—contain little or none where the beds *(veins)* are least productive; ‡‡ but they are more or less impregnated to greater or smaller distances in proportion to the dimensions and qualities of the *bunches* of gold they adjoin.§§

(*f.*) The upper talcose rocks ‖‖ are separated from

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* *Ante*, pp. 215, 219, 223, 239, 244—5; *Table VIII.* columns 3, 6, 9, 12, 15, 18, 21.

† *Ante*, pp. 228, 237, 254; *Table VIII.* columns 3, 21.

‡ *Ante*, pp. 228, 234, 239, 245, 247, 254; *Table VIII.* columns, 3, 6, 9, 12, 15, 18, 21.

§ *Ante*, p. 230.

‖ *Ante*, p. 246.

¶ *Ante*, pp. 215, 223, 230, 239, 244, 245, 255; *Table VIII.* columns 3, 6, 9, 12, 15, 18, 21.

** *Ante*, pp. 223, 228, 234, 240, 247, 255; *Table VIII.* columns 3, 21.

†† *Ante*, pp. 228, 230—3, 246, 257, 262—4, 266—7, 269, 277; *Table VIII.* columns 6, 9, 12, 15, 18.

‡‡ *Ante*, pp. 263, 282; *Table VIII.* columns 9, 12, 15, 18.

§§ *Ante*, pp. 215-16, 219, 245, 255, 257—8, 277; *Table VIII.* columns 3, 6, 15, 18.

‖‖ *Ante*, pp. 300—4.

the lower * by the iron-series (*Itabirite* † and *Jacotinga* ‡) only, at *Boa Vista, Pitangui, Morro das Almas,* and *Agoa Quente* north-east of the Caraça; but by the clay-slate § as well as by the iron-formation at *Gongo Soco.* The former is often of reddish or brownish hue,‖ the latter of pale buff* colour; one is mostly interlaid by thin ribs,¶—the other by broad bands,* of quartz mingled with slate; but the gold they afford is distributed in the same manner; and the same alloy **—unrecognised in the intermediate strata—is common to both. If, however, other relations subsist between them,†† they are concealed either by vegetation,‡‡ or by the *Canga.*§§

The upper calcareo-siliceous rocks ‖‖ enwrap small masses of milk-white quartz sprinkled with particles of gold; so thinly, however, that the formation remains to this day unwrought.

Every gold-bearing bed partakes the mineral character of the rock it interlies.¶¶

(*g.*) The *Canga,* which overlies—the iron-series at

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* *Ante,* pp. 176—80.

† *Ante,* pp. 211, 214, 219, 221, 224–5, 248, 311.

‡ *Ante,* pp. 214, 219, 223, 225, 237, 243, 245, 247, 254, 313.

§ *Ante,* pp. 182—207, 311; *Table VI.* columns 2, 5, 8, 11, 14, 17, 20.

‖ *Ante,* p. 246,

¶ *Ante,* pp. 300—4.

** *Ante,* pp. 180, 299; *Table X.* column 17.

†† The late H. Virgil von Helmreichen,—an experienced and a careful observer,—believed the iron-rocks to be enveloped in the slate-formation.

‡‡ *Ante,* pp. 241, 296.

§§ *Ante,* pp. 217, 236, 245, 247–8, 299, 303.

‖‖ *Ante,* p. 204.

¶¶ *Ante,* p. 23, Note†.

Itabira, Durañ, Cocáes, and *Gongo Soco,**—talcose slates at *Agoa Quente, Descoberta,* and *Thesoureiro,*†—and calcareous rocks at *Gongo Soco;*‡ consists mostly of iron-glance, *Itabirite, Jacotinga,* oxydulated iron, and quartz, in sub-angular blocks; cemented by either red or brown iron-ore, often massive, but sometimes in an earthy state: crystalline particles of gold § occur at intervals; and in at least one instance it also contains native copper.‖

(*h.*) From a mixture of granular quartz, talcose clay, and earthy red iron-ore,—which succeeds the *Canga* ¶ and overlies the low-grounds,—small quantities of gold are occasionally collected during the rains.

(2.) *Structure.*—(*a.*) No peculiarity of structure distinguishes the auriferous from the ordinary granite of *Candonga.***

(*b.*) Although the massive beds of gold-bearing quartz which occur in the lower talc-slate †† exhibit many flexures, they generally conform to its schistose structure.

(*c.*) The thick-bedded quartz-rock of *Catta Preta* ‡‡ differs in composition from the auriferous bands and their *(branches)* offshoots, §§ only in that it contains mere traces of compact red iron-ore and of gold;

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* *Ante,* pp. 216, 236, 245, 248.
† *Ante,* pp. 298, 300, 302.
‡ *Ante,* p. 298.
§ *Ante,* pp. 217, 236.
‖ *Ante,* p. 236.
¶ *Ante,* p. 308.
** *Ante,* p. 175.
†† *Ante,* pp. 178—80, 313.
‡‡ *Ante,* pp. 180—2.
§§ *Ante,* p. 181, *Fig.* 13.

whilst they afford small quantities of both. It is generally of granular structure and pale-buff or brownish-red hue; but they — here and there enclosing small granular masses — are mostly crystalline and transparent.

(*d.*) The only productive members of the clay-slate series are broad beds, composed in great measure of quartz; but containing also large quantities of quartzose slate and iron-pyrites, beside other substances in less abundance.* Some of these — each but a few fathoms long—interlie the laminæ at intervals, but terminate at the seams; † others—of greater length—conform to the cleavage in certain parts of their range, follow the joints elsewhere, and here and there—but less frequently—are oblique to both.‡ Between them and the *(Country)* rock on either side there is often a gradual transition; § but sometimes their junctions are well defined.

Wedge-shaped bodies *(horses)* ‖ of slate, not uncommonly, split the largest beds *(Pl. III.)*; and angular blocks, of various sizes,— enveloped in the quartzose and pyritous matrix—form, occasionally, considerable portions of the metalliferous mass: but—whether they are wholly or partially separated from the neighbouring

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* *Ante*, pp. 182—210, 312.

† *Ibid*, pp. 183, 247, Note ††.

‡ *Ibid*, pp. 186, 188.

§ Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, & Dublin Phil. Mag.*, XXV. p. 342; *Ante*, p. 194, 313.

‖ Henwood, *Cornwall Geol. Trans.*, V. pp. 176, 210; *Ante*, p. 194; *Table VI.* column 11.

strata,—their cleavage, unimpaired, maintains on the whole a tolerable, though not in every case an exact, uniformity.*

Those portions of the auriferous deposits which either intersect the rocks or conform to their joints at *Morro Velho*, are now and then partly or entirely severed by certain beds or *floors* of slate, integral parts, projecting from either of, or from both, their sides *(walls)*.†

At *Ouro Fino* ‡ a concentric-lamellar structure prevails in the spheroidal masses,§ of clay-slate and of fibrous white iron-pyrites, which abound in the productive band of quartzose slate.

(*e*.) The rich though narrow beds of auriferous *Jacotinga* conform to the generally schistose structure of the iron-formation ; ‖ and—in an instance or two—less productive offshoots from them follow the joints.¶ But—seldom or never ranging independently across the strata—these yield little gold, and are traced with difficulty in the massive crystalline iron-glance.**

At *Gongo Soco* the *Jacotinga* and the triangular

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* *Ante*, p. 190, 313.

† *Ibid*, pp. 191—3; *Fig*. 15 ; *Table VI*. columns 5, 8, 11.

‡ *Ante*, p. 184.

§ Carne, *Phil. Trans*., XCVIII. p. 293; *Cornwall Geol. Trans*., II. p. 94. De Luc, *Geological Travels*, III. p. 278. Weaver, *Geol. Trans*., V. p. 171. Henwood, *Cornwall Geol. Trans*., V. pp. 36, 72, 157, 183; *Tables VI., XXXIV., LVIII.* Salmon, *Quarterly Journal of the Geol. Society*, XVII p. 183. Wallace, *Geological Structure of Alston Moor*, p. 99. Laur, *Annales des Mines*, 6me Série, III. p. 423.

‖ *Ante*, pp. 214, 221, 223-4, 227, 229-30, 236, 245, 262—86.

¶ *Ibid*, p. 264; *Table VIII*. column 6.

** *Ibid*, pp. 254, 256.

mass *(horse)* of *Itabirite* which interlies it, have the selfsame planes of cleavage in common.*

(*f.*) The auriferous beds of quartz — whilst more numerous,—are, for the most part, shorter and smaller in the upper † than in the lower ‡ talc-slate. But— though conforming, generally, to the cleavage,§—they diverge at the joints and cross the strata ‖ more frequently than similar, but larger, beds in other parts of the series.

The massive calcareo-siliceous rocks,¶—the ferruginous breccia ** *(Canga)*,— and the widely-spread deposit of granular quartz and talcose clay,††—have already been mentioned in, perhaps sufficient, detail.

The relations borne to certain adjoining strata, by the thin lines of gold contained in that part of the matrix which conforms to the joints, at *Pitangui* ‡‡ and at *Agoa Quente*; §§ as well as those which the *shoots* of rich *Jacotinga*, and of auriferous pyrites imbedded in quartz, bear both to the composition and to the undulating *(rippled)* conformation of the schistose iron-glance at *Gongo Soco*,‖‖ and of the clay-

* *Ante*, pp. 251, 265; *Table VIII.* column 21.

† *Ibid*, pp. 298, 301, 303.

‡ *Ibid*, pp. 178—80.

§ *Ibid*, pp. 178, 180, 298, 301, 302; *Table X.* columns 4, 5, 11, 12.

‖ *Ibid*, pp. 299, 301—2; *Table X.* columns 7, 8, 11, 12.

¶ *Ibid*, p. 304.

** *Ibid*, pp. 216, 236, 245, 248, 299.

†† *Ibid*, pp. 308, 316.

‡‡ *Ibid*, pp. 223—4.

§§ *Ibid*, p. 234.

‖‖ *Ibid*, pp. 263—4, 266—7, 269.

slate at *Morro Velho*,*, may, perhaps, be more conveniently recapitulated hereafter.

E.—*Distribution of gold in different rocks.*

(*a.*) The granite of *Candonga* † is irregularly sprinkled with small crystalline masses of oxydulated iron; and, more thinly, with particles, grains, dendritic groups, and reticulated threads of gold.

(*b.*) Portions of the lower talc-slate at *Santa Rita*,‡ and of the upper at *Fraga*,§ are charged with earthy brown iron-ore, and sparingly mixed with gold.

The most productive parts of both series, however, are certain beds, of which some—in the upper talc-slate especially—are short and narrow; ‖ but others are of great length, depth, and thickness.¶ Quartz is always their chief constituent; but earthy brown iron-ore is a frequent, and sometimes an abundant, ingredient; whilst oxydulated iron, iron-glance, and several other minerals are also common.** Here and there gold is scattered through portions of these vein-stones in much the same manner as through the granite; †† but the richest parts are generally those which contain most iron-ore.‡‡

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* *Ante*, pp. 206—7.

† *Ibid*, pp. 175, 311.

‡ The talcose slate of *Santa Rita* afforded from 0·0000008 to 0·0000055 its weight of gold. *Ibid*, p. 177.

§ *Ibid*, p. 301.

‖ *Ibid*, pp. 178, 299, 302.

¶ The broad band of quartz wrought at *Catta Branca* yielded from 0·0000065 to 0·0000196 its weight of gold. *Ibid*, p. 179.

** *Ibid*, pp. 178—80, 298—303.

†† *Ibid*, p. 319.

‡‡ *Ibid*, pp. 177, 299, 301—2.

(*c.*) The thick-lamellar quartz-rocks of *Catta Preta* are interlaid by crystalline beds and *floors* of colourless quartz. In these, minute crevices without number are commonly filled with earthy red iron-ore; through which small quantities of gold are sometimes thinly sprinkled.*

(*d.*) The clay-slate of *Morro Velho*—slightly transfused with pyrites at intervals,—yields small quantities of gold † to some distance from the large deposit of pyritous quartz, with which it unites by gradual changes of mineral character.‡

But in this, as well as in the talc-slate,§ formation the riches are mostly obtained from particular beds, which —now and then of short range,|| but often of great extent,—commonly interlie the planes of cleavage,¶ though certain portions conform to the joints,** and others are oblique to both.†† These, as already mentioned,‡‡ consist mostly of quartz; largely mixed, however, with earthy brown iron-ore near the surface; but with enormous masses of quartzose slate and of

* 0·0000132 their weight of gold was obtained from the beds of quartz at *Catta Preta*. *Ante*, pp. 182, 316.

† From 0·00000143 to 0·00000353 its weight. Treloar, Walker, Reay, and Symons, *Reports of the Saint John d'el Rey Company*, XX. p. 53; XXIV. p. 43; XXXI. pp. 45—8; *Ante*, pp. 186, 196.

‡ *Ante*, p. 194.

§ *Ibid*, p. 319.

|| *Ibid*, p. 183.

¶ *Table X.* columns 4, 11.

** *Ibid*, columns 7, 11.

†† *Ibid*, columns 4, 7, 11.

‡‡ *Ante*, pp. 182—4, 190, 194, 202, 312, 317; *Table VI.* columns 5, 8, 11, 14, 17, 20, 23.

iron-pyrites, in which smaller quantities of arsenical and of copper-pyrites, and cavities lined with crystals of spathose iron, arragonite, and quartz, are enclosed at greater depths. Through the siliceous ingredients gold is mostly distributed * in much the same manner as through corresponding parts of the talc-slate; † but sometimes it is determined to the crevices; ‡ which in a few cases are as numerous as in the quartz-rocks. Through the more deeply seated pyritous portions,§ likewise, gold is (by assay) found irregularly distributed; || but whether these inequalities depend on differences in the sizes or in the numbers of the granules, is unknown; for the metal is so minutely divided,¶ that it is undistinguishable by the naked

* Ferruginous quartz from the *Camara* mine yielded 0·000000744 its weight of gold. *Ante*, pp. 182, 247.

† *Ibid*, p. 320.

‡ *Ibid*, p. 182.

§ "At a" gold "mine in Orange County"—Virginia—"which I visited the "contents of the vein became more and more pyritical as it descended, until, at "a depth of one hundred and twenty feet, no more quartzose matter appeared, "and the entire vein was composed of a finely granulated sulphuret of iron."
Featherstonhaugh, *Excursion through the Slave States*, II. p. 356.

|| At *Ouro Fino* the pyrites yielded 0·0000140 its weight of gold.
John George Goodair, Esq., MSS.
Ante, p. 184.

Monthly assays of pyritic ore at *Morro Velho* range from 0·0000145 to 0·0000395,
and average .... 0·0000229,
but selected specimens afford.... 0·0001835.

Reports of the Saint John d'el Rey Company, XXVI.—XXXII. *Ante*, p. 197. *Table VIa.* Treloar, *Report of the Saint John d'el Rey Company*, XXIV. p. 26. *Ante*, p. 197, Note ‡.

¶ "In some instances the crystalline structure of the pyrites is beautifully "exhibited" in the mines of Virginia, "the incipient decomposition of the crys- "tal showing the complex laminated structure of the interior, where bright "laminæ of native gold are seen leaning against the parietes, with transparent "crystals of sulphur formed from the decomposition of the sulphuret."
Featherstonhaugh, *Excursion through the Slave States*, II. p. 355.

eye.* In the matrix most congenial to gold at *Morro Velho,* however, pyrites is leavened with quartz.†

The *North Branch* ‡ and great part of the principal deposit § conform to the cleavage ‖ of the adjoining slate: ¶ in both the larger masses ** *(shoots)* of ore —coinciding with its undulations †† *(ripples)*—dip towards the east; and both—like the beds of *Jacotinga* at *Agoa Quente* ‡‡ and *Gongo Soco* §§—are productive on the same meridian. Smaller portions of the principal formation, however, follow the joints; ‖‖ and in such—as in the iron-formation at *Pitangui* ¶¶ and *Agoa Quente* ***—the richer and the poorer parts respectively, are bounded by the edges of widely dissimilar strata.

(*e.*) The calcareo-siliceous portion of the *Itabirite* ††† —wrought only at *Cocäes* and *Gongo Soco* in the same

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* Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, & Dublin Phil. Mag.*, XXV. 3rd series, p. 342.

† Treloar, *Reports of the Saint John d'el Rey Company*, XXX. p. 25; XXXI. p. 28. *Ante*, p. 197.

‡ *Ante*, p. 191; *Table VI.* columns 21—3.

§ *Ante*, p. 187; *Table VI.* columns 3—11, 15—17.

‖ *Ante*, p. 188.

¶ After the principal deposit and the *North Branch* have been wrought; it is impossible to support, in its natural position, the soft, jointed, thin, inclined mass of slate ("the tongue of killas") which divides them at the *Bahù.*

** *Ante*, p. 206; *Table VI.* columns 3—23.

†† *Ante*, p. 207.

‡‡ *Ante*, p. 229; *Fig.* 18.

§§ *Ante*, pp. 267—8.

‖‖ *Ibid*, p. 188.

¶¶ *Ibid*, p. 224.

*** *Ibid*, p. 234.

††† *Ibid*, pp. 245, 249.

range—has yielded merely a few thinly-sprinkled grains of gold.*

(*f*.) The iron-formation—which succeeds, and at times encloses *(horses)* † masses of the *Itabirite*,—consists in great measure of iron-glance,‡ mixed in some places with smaller quantities of both black § and brown ‖ earthy iron-ore, in others with oxydulated¶ and titaniferous** iron, and elsewhere with hydrous iron-ore.†† Sometimes, however, the iron-glance is replaced by pale-brown earthy iron-ore; ‡‡ and quartz —thinly sprinkled with iron-pyrites §§—then becomes a large ingredient.

Where micaceous iron-ore abounds ‖‖ the formation bears a schistose character; and even when granular iron-glance is mixed with earthy ores traces of lamination ¶¶ still prevail; at intervals, however, large bodies are of crystalline and massive structure.***

* The best parts afforded but 0·0000000021 their weight of gold. *Ante*, p. 249.

† *Ibid*, pp. 251, 265; *Table VIII.* columns 3, 18, 21; *Fig.* 21.

‡ *Ibid*, pp. 214, 219, 221—4, 227, 237, 243—4, 247, 254, 256, 260—70, 313; *Table VIII.* columns 3, 6, 9, 12, 15, 18, 21.

§ *Ibid*, pp. 254, 256, 263, 314; *Table VIII.* columns 3, 6, 12, 15, 18, 21.

‖ *Ibid*, pp. 217, 223, 228, 239—42, 246, 254, 256—7, 262—7, 314; *Table VIII.* columns 6, 9, 12, 15, 18, 21.

¶ *Ibid*, pp. 214, 219, 225, 228, 237, 242, 248, 252, 257, 262, 265, 270, 314; *Table VIII.* columns 3, 15, 18, 21.

** *Ante*, p. 228.

†† *Ibid*, pp. 225, 246, 263. *Bulletin de la Société Géologique, de France*, XXI. (1863) p. 25.

‡‡ *Ante*, p. 265.

§§ *Ibid*, p. 256.

‖‖ *Ibid*, p. 254.

¶¶ *Ibid*, p. 269.

*** *Ibid*, pp. 260, 270.

The auriferous portions of such crystalline rocks seldom exceed a few inches in width; * but those of the micaceous-iron slates often measure many feet; † and amongst the granular and earthy ores they sometimes extend several fathoms.‡ But even of these the greater part is very slightly sprinkled with gold; § for the poorer (0·999) nine hundred and ninety-nine one thousandth parts of the *(Jacotinga)* ore wrought at *Gongo Soco*, afforded (only 0·323) scarcely one-third ‖ of the entire produce.

The great riches of this series have, however, been obtained from certain conformable beds, already mentioned; ¶ which open, at intervals, to a width of two or three, and in extreme cases of six inches,** for several feet, or even fathoms, in length and depth.†† These—partaking, like all other metalliferous deposits, the nature of the adjoining rocks—consist, in great measure, of iron-glance, black and brown earthy iron-ore, manganese, and talc; mixed at times with smaller

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* *Ante*, pp. 254, 256, 270.

† *Ante*, pp. 214, 216, 242.

‡ *Ante*, pp. 227, 245, 255; *Table VIII.* columns 6, 15, 18.

§ *Ante*, pp. 215, 219, 222, 224, 234, 236, 242, 245, 247, 255, 257—8, 274, 277, 281.

The *(Jacotinga)* ore *stamped* at *Gongo Soco* yielded from 0·000000191 to 0·000000765 its weight of gold. *Ante*, p. 255; *Table X.* column 9.

‖ *Ante*, p. 277; *Table IX.* columns 44—6.

¶ *Ante*, pp. 229, 262, 314, 318.

** *Ante*, pp. 228, 230—4, 246, 262—8, 314, 318; *Table VIII.* columns 5, 8, 11, 14, 17, 20.; *Table X.* column 13.

†† *Ante*, pp. 216, 228, 230, 232—4, 257, 266—7, 269, 271, 279—80, 283; *Table VIII.* columns 6, 12, 15, 18, 21.

proportions of other ingredients.* The central—which are frequently the most congenial—portions of this matrix, contain rough *(nuggets)* lumps, flakes, and granules; sometimes isolated, often clustered, but generally united by intertwining threads of gold.† Towards the sides and edges of the *bunches*, however, smaller grains and particles of gold are more thinly sprinkled through the vein-stones; ‡ which—becoming poorer by degrees and at length ceasing to afford gold—merge, ultimately, in the neighbouring strata.§ At *Gongo Soco* the widest and softest parts of the iron-formation contained several productive beds; ‖ in which—as in those of the clay-slate at *Morro Velho* ¶—the richest *(shoots) bunches* ** occurred, as well on corresponding undulations †† (flutings or *ripples*) of the (*Country*) rock, as on the same meridian.‡‡ These formed in the aggregate less than (0·001) a one-thousandth part of the ore extracted; but they yielded

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* *Ante*, pp. 223, 228, 233, 263—5, 268, 313; *Table VIII.* columns 6, 9, 12, 15, 18, 21; *Table X.* columns 13, 14.

† *Ante*, pp. 272—3; *Table VIII.* columns 6, 12, 15, 18, 21.

‡ *Ante*, p. 274.

§ *Ibid*, p. 325.

‖ *Ibid*, pp. 272—3; *Table VIII.* columns 6, 15.

An English miner, who afterwards became Captain of a neighbouring gold-mine, was one day found sending to the *Stamps* all the ore he was breaking; unconscious that, within a width of eight or ten inches it contained two thin parallel lines of *tough* gold. MSS. of the late CAPTAIN THOMAS PENGILLY.

¶ *Ante*, pp. 188—92, 323; *Table VI.* columns 2, 8, 11, 14, 23.

** At *Agoa Quente* the *bunches* yielded from 0·000379 to 0·017232 their weight of gold;
„ *Gongo Soco* „ „ 0·003273 „ 0·521123 „
Ante, pp. 231, 235, 279—80.

†† *Ibid*, pp. 267—9; *Table VIII.* columns 15, 18, 21.

‡‡ *Ante*, p. 269.

(0·677) more than two-thirds of the gold obtained.* The produce of these central portions, therefore, is as much above, as that of those towards the sides is below, the ordinary yield of the beds wrought in talcose slate at *Catta Branca* and in clay-slate at *Morro Velho*.†

In the same mountain-range the mines of *Soares*‡ and *Camara* also yield gold, but on other meridians.

Whether the auriferous beds—occur only beneath the surface and after short ranges disappear as well

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* *Ante*, p. 977; *Table IX.* columns 44—6; *Table X.* column 15.

† At *Gongo Soco*, [of gold;

the central portions yielded *a*	from 0·003273000	to 0·521123000	their weight
,, the exterior ,,	,, 0·000000191	,, 0·000000765	,,
At *Catta Branca* (1840—1844),			
the annual averages *b* .. were	,, 0·000006500	,, 0·000001960	,,
At *Morro Velho* (1838—1860),			
the annual averages *b* .. were	,, 0 000051888	,, 0·000018691	,,

Ante, pp. 179, 255; *Table VII.* column 25.

The cost of materials, labour, &c.,

at *Gongo Soco*, from 1826 to 1836, averaged	£25 : 13 : 0
Morro Velho, ,, 1835 ,, 1860, ,,	26 : 5 : 4

per lb. *(Troy)* of gold extracted.

Table VII. columns 26, 35; *Table IX.* columns 46, 64, 65, 67.

" Sometimes in the midst of the poorest minerals we find very considerable " masses of native silver; a phenomenon which appears to depend on a particular " operation of chemical affinities, with the mode of action, and laws of which " we are completely ignorant. The silver in place of being concealed in galena, " or in pyrites in a small degree argentiferous, or of being distributed throughout " all the mass of the vein over a great extent, is collected into a single mass. " In that case the riches of a point may be considered as the principal cause of " the poverty of the neighbouring minerals; and hence we may conceive why " the richest parts of a vein are found separated from one another by portions " of *gangue* almost altogether destitute of metals."

De Humboldt, *Political Essay on the Kingdom of New Spain*, iii. p. 161.

" Whatever may be the positions and dimensions of these bodies of" (tin and copper) " ore, they are usually altogether isolated and separated from each " other by the earthy minerals of which by far the largest part of every *lode* " consists."—Henwood, *Cornwall Geol. Trans.*, v. p. 210.

‡ *Ante*, p. 182.

§ *Ibid*, pp. 183, 247.

a At the *Washing-house*. *b* At the *Stamps*.

upward and downward as at both ends,* or—cropping out—are of great but unknown length and depth; †—are but a few inches,‡ or many feet, wide; §—follow the joints,|| or conform to the cleavage; ¶ particles of gold are disseminated singly through the iron-pyrites; ** but *(nuggets)* masses—of larger sizes as their matrix is of better quality ††—are clustered in the specular ore they contain.‡‡

F.—*Characters of the vein-stones, and proportions of gold obtained from them, at different depths.*

(*a.*) As the metalliferous deposits of *Morro Velho* are followed downward they enclose masses of slate in greater numbers, §§ become wider |||| and softer, ¶¶

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* *Ante*, pp. 177, 183, 266—7, 269, 299; *Table VIII.* columns 13—21.

† *Ante*, pp. 178, 181, 184, 188—207, 214, 216, 301; *Table VI.* columns 3—23.

‡ *Ante*, pp. 177, 183, 214, 228—32, 262—8, 299, 302; *Table VIII.* columns 5, 8, 11, 14, 17, 20.

§ *Ante*, pp. 178, 182—4, 189—90, 214, 216, 240, 253—4, 301; *Table VI.* columns 4, 7, 10, 13, 16, 19, 22.

|| *Ante*, pp. 181, 187—8, 207, 221, 223, 232, 234, 264, 299, 301—2; *Table VI.* column 14; *Table VIII.* column 6.

|| *Ante*, pp. 177—8, 182—4, 187—8, 207, 214, 216, 221, 223, 227, 238, 244, 251, 255, 259, 262, 266—7, 269 282, 299, 301—3; *Table VI.* columns 5, 8, 11, 17, 20, 23; *Table VIII.* column 1.

¶ *Ante*, pp. 184, 194—8, 312, 318, 322; *Table VI.* columns 5, 8, 11, 14, 17, 20, 23.

** *Ante*, pp. 177, 181, 183, 299, 301—2, 312, 320.

†† *Ibid*., pp. 216 Note ‡, 224, 230—5, 271—80, 326; *Table VIII.* columns 6, 9, 12, 15, 18, 21.

Iron pyrites............	contains......	47·85 per cent. of metal;		
Earthy brown iron-ore ..	,, ...	56·13	,,	;
Iron-glance............	,, ...	69·00	,,	;

Phillips, *Mineralogy* (3rd Edition, 1823), pp. 217, 224, 231.

‡‡ *Ante*, pp. 202, 212 Note ||.

§§ *Ibid*, pp. 190, 206. |||| *Ibid*, p. 199. ¶¶ *Ibid*, p. 194.

afford more arsenical pyrites,* less quartz,† and smaller proportions of gold.

(*b.*) In the shallower parts of *Gongo Soco* an imperfectly lamellar structure ‡ pervades the body of granular iron-glance, black and brown earthy iron-ore, manganese, and talc; which—interlaid by these beds, whence the great riches of this formation are derived,§—is, for some distance beside them, more or less impregnated with gold.‖ Somewhat deeper it is more decidedly schistose,¶ and its chief ingredients are iron-glance and talc; ** but in these the auriferous *bunches* are fewer, smaller, and less productive.†† At greater depths a fissile character prevails; iron-glance is to some extent replaced by yellowish-brown earthy iron-ore and oxydulated iron,‡‡ the talc is mingled with quartz,§§ and crystals of iron-pyrites occur at intervals; ‖‖ but here the deposit contains very little gold.¶¶ In all parts of the mine hard, crystalline, massive iron-glance seems to have an unfavourable influence.***

(*b*—1.) At *Agoa Quente* the iron-glance—everywhere quartzose, hard, and of schistose structure—is interlaid by two auriferous beds, usually less than one-tenth of an inch, but for short distances, here and there,

* *Ante*, p. 196.
† *Ibid*, pp. 201, 303 205—6.
‡ *Ibid*, pp. 269, 324.
§ *Ibid*, pp. 262—8, 311, 324.
‖ *Ibid*, pp. 263-4, 266-7, 271-80.
¶ *Ibid*, pp. 255, 281.
** *Ibid*, pp. 255, 265.
†† *Ibid*, p. 265.
‡‡ *Ibid*, pp. 265, 283.
§§ *Ibid*, pp. 256, 265, 267, 314, 324.
‖‖ *Ibid*, pp. 256, 265, 314.
¶¶ *Ibid*, pp. 256, 324.
*** *Ibid*, p. 283, *Table VIII.* column 21.
††† *Ante*, pp. 270, 318, 325.

several inches wide.* Although they generally conform to the cleavage; one of them is, in a single instance, slightly deflected at a short, thin *cross-vein* of quartz,† which accompanies one of the joints. The narrower parts consist chiefly of earthy brown iron-ore, iron-glance, and talcose clay; mixed, sometimes, with small quantities of titaniferous iron.‡ The broader portions likewise contain iron-glance and earthy brown iron-ore; but oxydulated iron, manganese, talc, and felspar clay are also abundant; and quartz is seldom wanting.§ In these grains and small *nuggets* are imbedded; sometimes singly, but frequently they are strung together by interlacing filigranes of gold.‖ The clusters, however, are fewer and smaller as their matrix —partaking the character of the neighbouring rock and of the *cross-vein*—becomes more and more quartzose at greater depths;¶ but in both the beds these *bunches* occur on the same parallels. From such groups some twenty-nine-thirtieths (0·966) of the entire produce are obtained.** About one-thirtieth (0·033) is also extracted from the adjoining rock; which for short distances beside the richest *bunches* is thinly sprinkled with gold.††

* *Ante*, pp. 230—2, 235.

† *Ibid*, pp. 232—4.

‡ *Ibid*, p. 230.

§ *Ibid*, pp. 228, 230, 233.

‖ *Ibid*, pp. 229, 233.

¶ *Ibid*, pp. 229—35.

** *Reports of the Imperial Brazilian Mining Association*, XLIV. p. 7; XLV p. 7; XLVI. p. 10; XLVII. p. 7; XLVIII. p. 6; XLIX. p. 9; L. p. 7; LI. p. 10; LII. p. 7; LIII. p. 18.

†† "The riches seem nowhere to extend far from the *Jacotinga*."—HENWOOD, *Ibid*, XLIII. second part, p. 2.

The following columns show the proportions of gold afforded by ore produced at different depths, in the clay-slate at *Morro Velho* and in the iron-slate at *Gongo Soco* and *Agoa Quente.*

Clay-slate.		Iron-slate			
Morro Velho.		*Gongo Soco.*		*Agoa Quente.*	
Depths. fms.	Proportionate yield of gold by crude ore.*	Depth. fms.	Proportionate quantity of gold extracted by each European miner.†	Depth. fms.	Proportionate quantity of gold extracted.‡
Surface to 50·0	1·	7 to 21	1·	12 to 27	1·
50· „ 100·0	0·956	21 „ 41	0·790	27 „ 37	0·462
100· „ 142·8	0·912	41 „ 55	0·450	37 „ 43	0·283

Thus, at progressively greater depths, the productive beds—so far as they are yet wrought—continue to yield smaller averages of gold. And these decrements are much more rapid when—as in the *Jacotinga*—rich *bunches* are aggregated in narrow layers; § than where —as in the quartzose and pyritous deposits—gold is more generally diffused through the matrix. ||

G.—*Quality of the gold in different rocks and at different depths.*

(1.) *Quality in various rocks.* The gold,—although disposed in much the same manner,—is of somewhat different quality in every member of the system.

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* *Ante*, pp. 205—6, 328; *Table X.* column 15.

† *Ante*, pp. 284, 329; *Table X.* column 15.

‡ *Reports of the Imperial Brazilian Mining Association*, XLIV.—LIII. *Ante*, pp. 227—235; *Table X.* column 15.

§ *Ante*, pp. 215 Note †, 216 Notes † ‡, 223, 227-235, 263-8, 271-4, 279-80.

|| *Ibid*, pp. 184, 194—8.

Rocks.	Vein-stones.	Qualities. Extremes.		Qualities. Means.
Granite	Granite—oxydulated iron	22 0·3—22 3·9		22 2·6*
Talcose slate	Quartz—earthy brown iron-ore—talc † *(Lower)*	20 3·0‡	—	22 1·2
	Quartz—talc—brown and black earthy iron-ore § *(Upper)*	—	23 3·5	
Quartz-rock ..	Quartz—red iron-ore	——		23 0·0 ‖
Clay-slate	Quartz—earthy brown iron-ore¶.	—	23 0·0	20 2·0
	Quartz — iron-pyrites — copper-pyrites—arsenical pyrites**..	17 3·8	—	
Iron-slate	Iron-glance — earthy black and brown iron-ore, talc, and manganese	20 0·0††	20 3·0‡‡	21 3·5

These averages must, however, be regarded only as approximations.

In the granite, in both the talcose slates, and in the quartz rocks, the gold is—with a few exceptions—of somewhat greater purity than in the clay-slates and in the iron-formation. And the enormous produce of *Morro Velho* is of inferior quality to the yield of smaller

* Percival Norton Johnson, Esq., F.R.S., MSS. Cock, *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, XXIII. p. 16. *Ante*, p. 175.

† Percival Norton Johnson, Esq., F.R.S., MSS. *Table X.* column 16.

‡ Lower talcose slate. *Ante*, pp. 176—80; *Table X.* column 16,

§ Upper talcose slate. *Ante*, pp. 298—304; *Table X.* column 16.

‖ von Spix und von Martius, *Reise in Brasilien*, I. p. 408. *Ante*, p. 180; *Table X.* column 16.

¶ In talcose clay-slate. *Ante*, pp. 182—3.

** *Table VII.* columns 27—9.

†† *Table IX.* column 47.

‡‡ Senr. Guarda-mór-Geral, Manoel Jozé Pires da Silva Pontes, *Voyage dans Provinces de Rio de Janeiro et de Minas Geraes* (Saint Hilaire), I. p. 273. *Ante* Note †; *Table X.* column 16.

During the year 1848 the gold obtained near *Itabira* averaged about 20 carats fine.

mines in other parts of the clay-slate. In like manner the large quantities obtained at *Gongo Soco* are of lower assay than the returns of inconsiderable deposits in the iron-slate elsewhere.

The calcareous strata are so thin, and the proportion of gold they afford is so small, that its character has never been determined.

Respecting the fineness of gold contained in distant parts of any single formation at the same horizon, we know but little. *Tables VII.* and *IX.*—compiled from Reports of the Saint John d'el Rey Company* and the Imperial Brazilian Mining Association †—supply, however, the means of ascertaining approximately

(2.) *The quality of gold obtained at different depths* in two of the largest and most productive mines.

Depth. fms.	Clay-slate.‡ *Morro Velho.* Quality of gold. Actual. carats	grains	Comparative.	Depth. fms.	Iron-slate.§ *Gongo Soco.* Quality of gold. Actual. carats	grains	Comparative.
Surface to 50·0	18	3·687	1·0	41 to 48	21	0·448	1.0
50· „ 100·0	19	0·183	1·006	48 „ 70	20	1·774	0·968
100· „ 142·8	19	0·228	1·008				

Whether the improvement in quality which, at progressively greater depths, gradually takes place in the gold of one mine, or the decline in that of the other; is owing to differences in the strata,‖ the vein-

* VIII.—XXXI. † XV.—LXII. ‡ *Ante,* pp. 205, 285; *Table* X. column 16.
§ *Ante,* p. 285; *Table* X. column 16.
‖ *Ante,* pp. 185, 25426—2, 269, 312—13, 321, 324.

stones,* and the alloys,† or to other causes; ‡ can hardly be discussed with advantage, in the present, imperfect, state of our knowledge.

H.—*The alloys of gold in various rocks and at different depths.*

(1.) *Nature and proportion of alloy in various rocks.*

Rock.	Alloy. Nature.	Alloy. Proportion of mass. Extremes.	Alloy. Proportion of mass. Means.
Granite	Palladium	0·050000—0·08000 §	0·070000
Talcose slate	Silver ...... ‖ (Lower) ..	....	0 114583
Talcose slate	Tellurium .... ‖ (Lower) ..	....	0·020834
Talcose slate	Antimony .. ¶ (Lower) ..	....	Traces.
Talcose slate	Bismuth .... ¶ (Lower) ..	....	Traces.
Talcose slate	Tellurium ...... *(Upper)* ..	....	Traces.
Quartz-rock ..	Silver	....	Traces.
Clay-slate	Silver .... ** †† ..	0·179300—0·205000	0·194200

* *Ibid*, pp. 194, 262—7, 313, 318, 325. † *Ibid*, pp. 206, 286; *Postea*, p. 335.

‡ *Ante*, pp. 199, 267, 270, 310.

§ Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., MSS. Cock, *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, XXIII. p. 16.

‖ Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., MSS.

¶ *Ante*, p. 180.

** John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS. *Table VII.* columns 2, 31.

†† Analysis of gold from *Morro Velho* (October, 1864).

Gold	0·7499
Silver	0·1793
Lead	0·0180
Bismuth	0·0135
Copper	0·0045
Antimony	0·0030
Arsenic	0·0105
Iron	0·0195
Mercury (traces) and loss	0·0018
	1·

John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS.

Rock.	Alloy. Nature.		Proportion of mass. Extremes.	Means.
Clay-slate ..	Copper	* ..	....	Traces.
	Lead.................	* ..	....	
	Bismuth	* ..	....	
	Antimony	* ..	....	
	Arsenic	* ..	....	
Iron-slate ..	Silver	† ..	0·044884—0·083333	0·053704
	Palladium	†‡ ..	0·038929—0·048054	0·042100
	Copper	§ ..	0·019444—0·037413	0·025374
	Platina	† ..	0·000407—0·001276	0·000811

Thus silver is more or less plentiful in every member of the succession,|| except the first.

* *Ante*, p. 334, Note ††

† *Reports of the Imperial Brazilian Mining Association*, XVI.–XXXI., Financial Statements. *Table IX.* columns 47—50. *Ante*, p. 236.

‡ *Ante*, p. 215.

§ *Ibid*, p. 334, Note ||

|| The mine-gold of Siberia is alloyed with silver, copper, and iron in the following proportions:—

Mines.	Metals, and their proportions. Gold.	Silver.	Copper.	Iron.	Totals.
Hiel	0·8740 ..	0·1260 ..	— ..	— ..	1·0000
Newiansk..........	0·9295 ..	0·0705 ..	— ..	— ..	1·0000
	0·8865 ..	0·1064 ..	0·0009 ..	0·0035 ..	0·9973
Beresow	0·9188 ..	0·0803 ..	0·0009 ..	— ..	1·0000
	0·9378 ..	0·0594 ..	0·0008 ..	0·0004 ..	0·9984
Katharinenburg	0·9280 ..	0·0702 ..	0·0006 ..	0·0008 ..	0·9996
Siranowski (Altai) ..	0·6098 ..	0·3838 ..	0·0033 ..	— ..	0·9969

" L'or et la platine se présentent dans l'Oural tres-fréquemment dans les mêmes " localités, il pouvait arriver que ces deux métaux se trouvassent aussi combinés " chimiquement." * * *

" Il paraît que l'or natif contient toujours au moins une petite quantité d'argent, " de cuivre, ou de fer." * * *

" En général la pesanteur spécifique de l'or, lorsqu'il a été fondu, est un peu " plus grande que celle de l'or tel que le présente la nature." * * *

" L'or que se trouve dans les filons a aussi une composition différente dans les " diverses parties d'une même mine." * * *

GUSTAVE ROSE, *Annales des Mines*, 3me Série, v. p. pp. 157—170.

" L'or et l'argent se trouvent unis ensemble dans la nature sous forme de cris-

Copper appears in the fourth and fifth strata; but in, at least, one instance* it is mixed, rather than alloyed with the gold.

Bismuth and antimony are not uncommon in the second section; † and both, as well as lead and arsenic, are met with in the fourth.‡

Palladium occurs in the first individual of the system; and—unrecognised in the intermediate formations—abounds again in the fifth.§

Tellurium abounds in the second; and,—undetected in any intervening deposit—re-appears in the last member of the series; but, as in the upper, it is also sometimes mixed with the gold.||

"taux, en toutes sortes de proportions, * * *. En général, les cristaux "dodécaèdres sont les plus riches en or, et ils n'en renferment pas moins de 0·91. "Viennent ensuite les tétraèdres, puis les octaèdres."

Awdeef, *Annales des Mines*, 4me Série, III. p. 845.

* von Eschwege, *Pluto Brasiliensis*, p. 298. *Ante*, p. 236.

† *Ante*, p. 180.

‡ John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS.

§ "When the Council determined in 1845 that Palladium was the fittest sub- "stance to employ for the Wollaston Medal, Mr. Percival Norton Johnson, "F.G.S., expressed a wish to present Palladium for that object, as a token of "his grateful esteem for Dr. Wollaston. The Palladium presented then being "at length exhausted, Mr. Johnson has again most handsomely offered to present "the Society with the requisite metal."

Quarterly Journal of the Geological Society of London, VII. (1851) p. 2.

This palladium was separated from the gold of *Gongo Soco*.

|| The thieves by whom a large consignment from *Catta Branca* was stolen on its arrival in London, were traced and convicted from Mr. Johnson's knowledge, that the gold was associated with tellurium.

"From amongst the stamped ore of *Catta Branca* I picked out particles of "tellurium."—Percival Norton Johnson, Esq., F.R.S., F.G.S., &c., MSS.

In Virginia the talcose slate is also interlaid by beds of quartz; which, at the *Garnett & Moseley* mines, afford gold alloyed in like manner with tellurium.

Postea.

Henwood, *Cornwall Geol. Trans.*, VII. p. 228. *Ante*, p. 180.

Platina is peculiar to comparatively shallow parts of the fifth group; but—occurring even there in small proportions,—it gradually disappears at greater depths; although the other metals, with which it had been associated, still abase the gold at a yet lower horizon.*

Platina and palladium are sometimes accompanied by minute quantities of still rarer metals;† but whether these exist in this district is unknown, as the gold is seldom examined for other than commercial purposes.

The following columns show the alloys natural to every member of the auriferous system:—

Alloys.	Rocks. Granite.	Talcose slate. (*Lower.*)	Quartz-rock.	Clay-slate.	Iron-slate.	Talcose slate. (*Upper.*)	Totals.
Silver ..	—	*	*	*	*	*	5
Copper ..	—	?	—	*	*	?	2
Antimony.	—	*	—	*	—	?	2
Bismuth .	—	*	—	*	—	?	2
Lead ..	—	?	—	*	—	?	1
Arsenic ..	—	—	—	*	—	—	1
Palladium	*	—	—	—	*	—	2
Tellurium.	—	*	—	—	—	*	2
Platina ..	—	—	—	—	*	—	1
Totals..	1	4	1	6	4	2	18

* *Ante*, p. 286; *Table IX.* columns 48—50; *Table X.* column 17.

† Tennant, *Phil. Trans*, xcIV. (1804) pp. 414, 416. Wollaston, *Ibid*, p. 419.

It has been already shown * that portions of the auriferous beds sometimes follow the joints for short distances, and thus intersect kindred strata; but they never, in a single instance, extend to even one other member of the system. Nor, indeed, are adjoining rocks, of diverse character, ever rich,—or more than slightly productive,—in the same neighbourhood.† The different alloys characteristic of gold in immediately sequent groups, therefore, occur, generally in distant districts.

(2.) *Proportion of alloy at different depths.*

Depth. fms.	Clay-slate. *Morro Velho.* Nature and proportion of alloy. Silver.	Copper, Lead, &c.‡	Depth. fms.	Iron-slate. *Gongo Soco.*‖ Nature and proportion of alloy. Silver.	Platina.	Palladium.	Copper.¶
50· to 100·	0·192400	?	41	0·058814	0·001276	0·038929	0·019444
100· ,, 142·8	0·199800	—	48	0·054759	0·000711	0·041974	—
			55	0·047614	0·000407	0·042700	—
			62	0·044884	—	0·048054	0·037413
Means	0·194200**	?	—	0·052991	0·000811	0·042100	0·025374

* *Ante*, pp. 181, 187, 223, 264, 298, 301—2, 311, 318—19, 321, 323.

† *Ibid*, p. 174.

‡ *Ibid*, p. 206; *Table VII.* columns 2, 30; *Table X.* column 17.

§ John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS. *Ante*, p. 334.

‖ *Ante*, p. 286; *Table IX.* columns 48—51; *Table X.* column 17.

¶ Percival Norton Johnson, Esq., F.R.S., &c., MSS.

** " A Gold-Hill (Californie), on exploite un gîte remarquable par la grande

The foregoing details supply less information than might have been desired; but they embody all within reach.

The proportion of each—irrespective of every other—alloy, at various depths, in rocks of the same, and of different, series; may, perhaps, be more readily seen in the following, than in the foregoing, columns.

" quantité d'or qu'il a fourni dès les affleurements. Ce gîte se compose d'une " série de veines de quartz juxtaposées l'une à l'autre, sortant d'un terrain de " schistes métamorphiques au pied d'un roc élevé de diorite. Ce gisement se " présente comme un puissant filon reconnu sur 180 mètres de long, large de " près de 40 mètres, incliné de 45° du côté de la diorite éruptive, et présentant " une masse de quartz aurifère d'au moins 25 mètres de large. Le gîte est coupé " en deux par un banc de schiste veiné de quartz, ayant 15 mètres de large. La " partie qui est au-dessus de ce banc be schiste se compose de deux filons de " quartz compacte de 1 à 3 mètres de puissance, comprenant entre eux une veine " de 2·5 à 4 mètres d'épaisseur, formée d'un sable quartzeux crystallin, empâté " par de l'argile et de l'oxyde de fer. Ces argiles contiennent aussi par places " de l'oxyde de manganèse en essez grande abondance pour les colorer en noir. " Les deux filons de quartz compacte sont aurifères, mais infinement moins riche " que la veine qu'ils comprennent, sur laquelle s'est concentrée l'exploitation."
* * *

" La partiê du gîte, située au-dessous du banc de schiste qui le recoupe en " deux, renferme trois filons de quartz compacte, comprenant entre eux deux " autres veines argileuses et quartzeuses, qui sont encore celles de plus grande " richesse." * * *

" On trouve à Gold-Hill un exemple remarquable de ce fait que, dans certains " filons, à mesure que les travaux gagnent la profondeur, l'or diminue et l'argent " augmente. Ainsi, à Gold-Hill, les proportions relatives de l'or et de l'argent " ont varié comme suit:

" Près des affleurements........	or, 651;	argent, 300;
" A 20 mètres de profondeur....	,, 462;	,, 450;
" A 50 ,, ,, ...	,, 33;	,, 931."

" Ce gisement de Gold-Hill n'est pas, à proprement dire, un véritable filon, " les travaux faits pour le reconnaître ont montré qu'il ne s'étendait pas au delà " de 200 mètres en direction, et que sa puissance allait en diminuant rapidement " du milieu du gîte à ses extrémités, de sorte qu'on doit considérer cet amas de " quartz aurifère comme un *gisement de contact*."

Laur, *Annales des Mines*, 6me Série, III. pp. 428—30.

Depth. fms.	Clay-slate. *Morro Velho.** Nature and proportion of alloy. Silver.	Copper, Lead, &c.†	Depth. fms.	Iron-slate. *Gongo Soco.*‡ Nature and proportion of alloy. Silver.	Platina.	Palladium.	Copper.§
50· to 100·	1·	?	41	1·	1·	1·	1·
100· „ 142·8	1·020	—	48	0·931	0·557	1·078	—
			55	0·809	0·319	1·097	—
			62	0·763	—	1 234	1·924
Means....	1·009	?	—	0·901	0·635	1·081	1·305

Whether the gold which, in similar vein-stones and rocks, is associated with the same metals in different parts of the Province ; ‖ as well as that which, in other matrices and strata, contains different alloy, in the same neighbourhood ; ¶ assumed its present place, at various times,** or at once,—however inviting as a subject for speculation—can scarcely be discussed, with advantage, in a descriptive memoir.

I. *Cross-veins,*

such as those which intersect the strata, for considerable

* *Ante*, p. 338, Note *. † *Ibid*, Note †. ‡ *Ibid*, Note ‡. *Ibid*, Note §.

‖ *Ante*, pp, 176—80, 298—304; 184—209 ; 214—98.

¶ *Ibid*, pp. 179—80, 184; 177, 181—2, 237—41; 182—3; 248—96.

** " Il est donc possible que ces filons (de la mine de *Beresow*) aient été formés " à diverses époques."—Gustave Rose, *Annales des Mines*, 3me Série, v. p. 169.

" We believe, that with the present amount of evidence, it would be unsafe to " attribute the origin, of either platinum or gold " (in the Ural), " exclusively " to one mode of formation."—Murchison, de Verneuil, & von Keyserling, *Russia in Europe & the Ural Mountains*, p. 484.

distances, in other countries;* are unknown in this district.

In the granite of *Candonga*,† nevertheless, portions of the auriferous beds,—which, at intervals, assume abnormal directions, and are poorer than the rest,—have been sometimes supposed to be affected by,—or even to be themselves—*cross-veins.*‡

At the *Camara* mine short, conformable beds of gold-bearing quartz, often end abruptly at the joints; but are now and then rediscovered, in contiguous *slices* of the clay-slate, by turning towards the *right-hand;* § sooner or later, however, they all disappear.

Both the *Itabirite* and the *Jacotinga* are traversed by *cross-veins* of quartz; which, at *Agoa Quente* || and *Gongo Soco*,¶ seldom exceed a fathom in length or depth, and are generally less than an inch in width.

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* Thomas, *Survey of the Mining District from Chacewater to Camborne*, p.p. 22—3. Carne, *Cornwall Geol. Trans.*, II. pp. 108—9. Forster, *Section of the Strata from Newcastle to Cross Fell*, pp. 73, 112, 206. Phillips, *Geology of Yorkshire*, Part II., pp. 99, 104, 107—8, 110—15. Fox, *Report of the Royal Cornwall Polytechnic Society* (1836) p. 88. De la Beche, *Report on the Geology of Cornwall, Devon, & West Somerset*, p. 303. Henwood, *Cornwall Geol. Trans.*, V. p. 255. Smyth, *Records of the School of Mines*, I. pp. 376, 394—9. Moissenet, *Annales des Mines*, 5me Série, XI, pp. 378—80—6, 592—6—8. Wallace, *On the Geological Structure of Alston Moor*, pp. 55, 104. *Ante*, pp. 124—6.

Mr. Carne's Memoir was communicated to the Royal Geological Society of Cornwall in 1818; Mr Thomas's work appeared in 1819; but Mr. Fox incidentally shows *(Cornwall Geol. Trans.* II. Pl. I. *Remarks)*, that the latter had been published, before the former was put to press.

† *Ante*, pp. 176, 311, 320.

‡ H. von Helmreichen, MSS.

§ *Ante*, pp. 183, 247, 327; *Fig.* 14.

|| *Ante*, pp. 225—6; *Fig.* 17.

¶ *Ante*, pp. 286—7; *Fig.* 25.

By some of these the strata are simply severed; but by others they are slightly displaced, and in such cases each bed in the upper side *(hanging-wall)* occupies a higher relative position than its counterpart in the lower side *(foot-wall)* of the *cross-course*. But, small as the displacements are, they diminish by degrees and at length disappear; * as—from their centres towards their circumferences—the *cross-veins* gradually decline, and ultimately merge, as well upward and downward as at either end, in undisturbed layers of quartz.

Detrital Gold.

In the beds and banks of rivers, as well as on the declivities of many mountains, the rock is covered with (*Cascalho*) sand, gravel, pebbles,† and subangular

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* Henwood, *Cornwall Geol. Trans*, v. pp. 88, 381.

† " Wherever the margin formed a flat, or level, the *cascalho* continued under " the surface to some distance, appearing like a continuation of the bed of the " river, which, in all probability, it was, as the river is known to have been much " wider formerly."—Mawe, *Travels in Brazil*, p. 268.

" On trouvait autrefois beaucoup d'or dans le voisinage de la rivière de Caeté." De Saint Hilaire, *Voyage dans le district des Diamans et sur le littoral du Brésil*, i. p. 127.

" Congonhas do Campo doit sa foundation à des mineurs qui trouvèrent beau-" coup d'or sur les rives du Rio de S. Antonio, ainsi que sur celles du Rio das " Congonhas et tout autour du village: le flanc des mornes déchiré, bouleversé " de toutes les manières, atteste assez les travaux des ces hommes aventureux." *Ibid*, p. 201.

von Eschwege, *Annales des Mines*, viii. p. 409; *Pluto Brasiliensis*, p. 229. Gardner, *Travels in Brazil*, pp. 505—6. Claussen, *Bulletins de l'Académie Royale de Bruxelles*, viii. 1re partie, p. 335.

" The gold alluvia of the Ural (sand it can very rarely be called) is a gravel " seldom less coarse than that around London and in the east of England, and " for the most part a shingle, composed chiefly of moderately-sized fragments of

rocks* of larger size, imbedded in ferruginous clay. All these, as well as the particles and grains of gold mixed with them, may be traced to their parent strata in the neighbouring *Serras.*†

Beyond these beds of *(Cascalho)* detritus the first seekers for gold did not extend their labours.

Early in the last century, however, the forests were recklessly destroyed‡ by the *(Roçeiros)* farmers. Laws

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" the adjacent rocks."—MURCHISON, DE VERNEUIL, & VON KEYSERLING, *Russia in Europe and the Ural Mountains*, I. p. 476.

" Le terrain diluvien ancien se compose d'une série de couches de galets de " sables et d'argiles superposées le plus souvent par ordre de grosseur. * * * " Tout ce terrain renferme de l'or. Les couches les plus riches sont toujours " celles de galets au de gros graviers."—LOUR, *Du gisement de l'or en Californie, Annales des Mines*, 6me Série, III. p. 411.

* " There is a difference between the *cascalho* in the mountains and that in the " rivers; the embedded stones in the mountain-*cascalho* are rough and angular, " but in that of the rivers they are rounded."

MANOEL FERREIRA DA CAMARA, *History of Brazil* (Southey), III. p. 827.

† Between Inficionado and Bento Rodriguez " I saw but little soil fit for " plantations, it being generally of a clayey nature, intermixed with a coarse " ferruginous gravel, or the *débris* of the schistose rocks of the Serra " de Caraça; " and everywhere this soil has been turned up in search of gold."

GARDNER, *Travels in Brazil*, p. 506.

" Unlike * * * other chains which burthened with much detritus have cast " off portions of it to great distances from their flanks, the sides of the Ural are " void of all such far-transported or rounded blocks; every loose fragment having " been derived from an adjacent elevation, and having been usually washed down, " in strict relation to the chief existing features of the land. In fact the term " *drift* is not correctly applicable to these Uralian masses, which are purely " local."—MURCHISON, DE VERNEUIL, & VON KEYSERLING, *Russia in Europe and the Ural Mountains*, I. p. 476.

" La couche aurifère d'Akstafa (au sud du Caucase) est recouverte d'alluvions " improductives formées de deux couches superposées, savoir : un mètre d'argile " grise et un mètre de galets disséminés dans la même argile. La composition " minéralogique de ces galets est la même que celle des roches avoisinantes."

ULAUYALY, *Annales des Mines*, 5me Série, III. p. 832.

" The gold-bearing gravels " of Victoria (Australia) " are the result of the " *immediate* waste of older masses, and have not been transported far."

SELWYN, *Quarterly Journal of the Geological Society of London*, XIV. p. 536.

‡ " A farmer made no scruple of setting fire to the woods, and laying waste " a tract of ten or twelve miles round his miserable plantation. The evil which

—still unrepealed, but never enforced—were immediately enacted for their protection;* but the mischief they were intended to prevent had been perpetrated; many of the springs—already laid bare—had vanished; and the works carried on by aid of the streams they afforded, had—of necessity—been abandoned. Of the *(Regos)* water-courses, thus rendered useless, many may still be traced, as well across the *(Campos)* open country, between Camargos and Inficionado, Cattas Altas and Brumado, Caëthé and Cuiabá, as in other parts of the Province, where now the traveller scarcely finds means to quench his thirst.

Beds to which water was easily brought from neighbouring rivers, however, were wrought either until they were exhausted, or until the workmen found more profitable employment in the mines. From all within reach, therefore, most of the gold has long † since been

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" would inevitably result from this havoc, was early foreseen, and Gomes Freire " de Andrada, at the commencement of his long administration, endeavoured to " prevent it."—Southey, *History of Brazil*, iii. p. 825.

* *Regimento dos Superintendentes, Guardos Môres, et Officiaes Deputados par as Minas do Ouro. Bando ou Additamento ao Regimento Mineral,* 13 *de Maio de* 1736. *Ante*, p. 138, Note.

† " Two lance-shaped arrow-heads "—presented to the Museum of American Antiquities at Copenhagen by Mr. von Helmreichen—were " obtained in the " process of washing the diamond-yielding *cascalho*, a soil consisting of sand and " small stones ; and both were found in the *batêa* or washing-bowl; but whether " they had been imbedded in the *cascalho* itself, or in the alluvial formation, Mr. " von Helmreichen was unable to ascertain. One of the arrow-heads is of petro- " silex, the other is of rock crystal. * * * The Indians now inhabiting the " Province of Minas Geraës make their arrow-heads of wood and bamboo, but " do not use stone for that purpose."

Journal of the Royal Geographical Society, xiv. (1844) p. 321.

" Fragments of worked metal were discovered on the river Shargan, a tribu- " tary of the Yenissey in Siberia * * * at a depth of fourteen feet eight inches " beneath the surface; near the middle of a bed of gold-bearing sand, which was

extracted; but, in the beds of many rivers, large quantities of rich *cascalho* still remain.*

The proportion of gold in this ancient detritus is unknown.†

"20 inches thick, and composed of yellow sand, pebbles, small fragments of "quartz, with other pulverized or decomposed rocks. Imbedded in it were "pieces of gold, varying in size from small grains to nuggets of one to four "pounds in weight. This deposit rested on a bed of rock."

Atkinson, *Quarterly Journal of the Geological Society of London*, xvi. (1860) p. 241.

"At Treloy, in Saint Columb-minor, *celts*, *brooches*, coins, and small rings of "brass were discovered *in* a bed of *stream*-tin-ore of small thickness covered by "about eight or ten feet of silt, sand, and vegetable mould."

Henwood, *Cornwall Geol. Trans.*, iv. (1828) p. 65.

* In an opening on the *cascalho*, beside the river of Socorro near Saõ Joaõ do Morro Grande, a chain-pump (Mawe, *Travels in Brazil*, p. 264; *Annales des Mines*, ii. p. 212) was worked by a water-wheel some twelve or fourteen feet in diameter, of which all the *gudgeons*, *arms*, *shrouding*, *backing*, *buckets*, *keys*, *wedges*, and *pins* were made of wood; bound together with the pliant tendrils of *(Cipós)* climbing plants.

† In the granite of Chili depressions and valleys frequently contain nearly horizontal beds of *(Cascajo)* shingle, gravel, sand, and clay; the comminuted portions of neighbouring rocks and *(lodes)* veins, which consist of quartz, felspar, mica, iron-glance, and the hydrous oxide of iron. These deposits,—which seldom exceed fifty yards in depth, but sometimes extend half a league—are scored with recent ravines which are not always coincident in direction with the ancient channels they now fill. All the alluvia are more or less auriferous throughout; but the deepest portions are ever the richest; of such the thickness is generally about a foot: but different deposits,—and even distant parts of the same beds are sometimes made up of different ingredients, which then yield gold of different qualities. Much of this gold occurs as dust or fine sand, but masses weighing from thirty to one hundred and fifty grains are numerous, and *nuggets (pepas)* of more than a Spanish pound (℔. 1·6 *Troy*) are now and then found. Small flakes abound, and thin dendritic plates are not uncommon; but the large lumps,—often flattish, and at times of cavernous or cellular structure, are always somewhat rounded. Their surfaces are usually smooth, but now and then they present roughish reticulations; sometimes also they are coated with the hydrous oxide of iron, and less frequently they are encrusted with quartz. Some of these deposits yield as much as 0·000078125, others no more than 0·000009681, their weight of gold.

Domeyko, *Annales des Mines*, 4me Série, vi. pp. 167—74 *(Abstract)*.

The following columns show the numbers of workmen employed, the quantities of sand washed, and the proportions of gold obtained from it, in various parts of Siberia during the year 1851.

Although existing rivers transport and abrade the

Districts.		Workmen.	Sand washed. Tons. (*Avoir.*)	Gold obtained. Quantity. lbs. (*Troy.*)	Gold obtained. Proportions of	Gold obtained. Per man per ann. lbs. (*Troy*)
			PRIVATE WORKS.			
Western Siberia.						
Tomsk	Tomsk	2,815	432,121·0	1,483·061	0·00000126	0·527
Yénisséysk	Atschinsk	722	90,077·1	292·067	0·00000119	0·404
	Minoussinsk ..	2,979	718,098·4	2,502·066	0·00000128	0·839
Kirghizs	Steppe....	695	74,266·2	160·678	0·00000079	0·231
Private Works		7,211	1,314,562·7	4,437·872	Means 0·00000124	0·615
			GOVERNMENT WORKS.			
Eastern Siberia.						
Nertschinsk	Transbaikalien .	3,698	269,549·3	2,984·710	0·00000407	0·807
Yénisséysk	Possolnaya	196	46,420·1	171·489	0·00000136	0·875
	Mourajnaya....	2,481	449,150·5	4,314·011	0·00000353	1·739
	Oudéréy	4,564	844,311·6	7,222·094	0·00000314	1·582
	Pit	913	173,937·4	678·587	0·00000143	0·742
	Pit (right bank)	2,901	660,792·9	7,370·807	0·00000409	2·541
	Podkaménnaya .	8,380	2,025,119·4	19,506·861	0·00000354	2·328
Kansk	Birussa	1,691	314,250·8	1,701·491	0·00000199	1·006
	Kouzéyéva	183	15,154·4	32·154	0·00000078	0·176
Irkoutsk	Oka	150	45,975·2	114·696	0·00000092	0·764
Werkhnéoudinsk ..	Tschikoya	974	164,944·8	862·450	0·00000192	0·885
	Witima	332	33,623·2	186·226	0·00000203	0·561
Olékminsk	Olékma	67	10,181·7	69·667	0·00000251	1·040
Government Works..		26,530	5,053,411·3	45,215·243	Means 0·00000329	1·704
Total......		33,741	6,367,974·0	49,653·115	Means 0·00000286	1·472

In the year 1851, therefore, each man employed
by private parties, on an average treated 182·3 tons of sand, and extracted 0·615 lb. of gold;
on Government Works, „ 190·3 „ „ 1·704 „ „ .

On all gold obtained by individuals from the sands of Siberia, the following Royalties (Rents and *Dues*) are reserved to the Crown;—

smaller and lighter portions of their beds, they are

Annual produce of Gold. Russian *poods*.	lbs. (*Troy*)	Royalties (Rents and *Dues*) reserved. Payable annually.	Number of tracts wrought, classed according to their produce, in 1851.
Less than 1	(— 43·878), ...	300 silver *roubles* (£48);	77
Between 1 and 2	(43·878— 87·756), ...	5 per cent. of the entire produce;	29
„ 2 „ 5	(87·756— 219·390), ...	10 „ „ ;	37
„ 5 „ 10	(219·390— 438·780), ...	15 „ „ ;	16
„ 10 „ 15	(438·780— 658·170), ..	17 „ on 10 *poods* (438·780 lbs. *Troy*); 25 „ on all the rest;	6
„ 15 „ 20	(658·170— 877·560), ..	20? „ on 15 *poods* (658,170 lbs. „); 28 „ on all the rest;	2
„ 20 „ 25	(877·560—1,096·950), ..	23 „ on 20 *poods* (877·560 lbs. „); 30 „ on all the rest;	3
„ 25 „ 30	(1,096·950—1,316·340), ..	25 „ on 25 *poods* (1,096·950 lbs. „); 32 „ on all the rest;	5
„ 30 „ 40	(1,316·340—1,755·120), ..	28 „ on 30 *poods* (1,316·340 lbs. „ ;) 33 „ on all the rest;	5
„ 40 „ 50	(1,755·120—2,193·900), ..	30 „ on 40 *poods* (1,755·120 lbs. „ ;) 34 „ on all the rest;	3
More than 50	(2,193·900 —), ..	32 „ on 50 *poods* (2,193·900 lbs. „ ;) 35 „ on all the rest.	2

In 1851 the Government granted 238 licences to search for gold.

utterly inadequate to the removal either of large rocks or of the heavier materials which are often ores of iron. Even whilst in flood they seldom overflow their banks, or rise to erode the strata.

Operations usually commence with May and end early in September, when snow begins to fall. This, however, does not arrest *the explorers*, who continue their labours through the winter; the frost hardening the marshy ground, and thus facilitating their work. But sometimes the sand is thawed with fire, and washed with tepid water; fuel—found on the spot—costing but little.

Contracts, between *the explorers* and *the workmen*, stipulate the number of barrows of sand each person is to remove daily; but having performed his task, the *labourer* disposes of his time as he pleases. The cost of treating the poorer sand averages (about one *rouble* and eleven *copecks* per cubic *métre*) nearly two shillings and nine pence per cubic yard. But, in addition to the terms of their ordinary agreements, *the proprietors* endeavour to encourage honesty and to prevent theft amongst their *workmen*, by offering rewards; which vary,—in proportion to the richness of the sand,—from (57·5 to 85 silver *copecks* per *zolotnick*) about eight pence to one shilling per pennyweight of gold obtained.

Each *workman* receives, beside his wages, 0·902 lb. *(Avoir.)* of meat, with an allowance of oatmeal daily; as well as bread and *kwass* (a sort of beer) "*à discrétion*."

How *the explorers* manage to get through their rough work during winter is truly surprising; as huts made with the branches of trees, and often covered with snow, are their only shelter from the severity of the weather. In spite of these hardships, however, *explorers* are always on the increase.

Ulauyaly, *Annales des Mines*, 5me Série, iii. pp. 821—30 *(Abstract)*.
Whitney, *Metallic Wealth of the United States*, p. 89.

Between Bâle and Bingen the Rhine winds through an enormous deposit of sand, gravel and shingle; made up, in great measure of granite, micaceous and talcose quartz-rocks of schistose structure, siliceous sandstones, hornblendic slates, porphyries, serpentines, and limestones. A few of these resemble the volcanic rocks of Kaiserstuhl, others seem to have come from the Jura, many are natives of the Vosges and of the Black Forest, but the greater number by far are of Alpine origin.

Traces of gold occur in the pebbles of quartz which are obtained from this formation for paving the streets of Bâle, Strasburg, Brisach, and other neighbouring towns. The sand and gravel, as well in both banks as at several miles from the river, are more or less auriferous; but they yield only from 0·000000090 to 0·000000100 their weight of gold.

These, more ancient deposits, are, at intervals, overlaid by the *Loess* (a formation of argillaceous matter, carbonate of lime, quartzose sand, and micaceous clay; enclosing land-shells of recent species), which is utterly barren.

Daubrée, *Annales des Mines*, 4me Série, x. pp. 1—21. *(Abstract.)*

During the calms of the hot season heavy rain*

* RAIN
at

Gongo Soco. a
Long. 43° 30′ W.; Lat. 18° 58′ 30″ S.;
about 3,360 feet above the sea.

Morro Velho. b
Long. 43° 50′ W.; Lat. 12° 58′ 20″ S.
about 3,250 feet above the sea.

Months.	1845. Rainy days.	1845. Rain. ins.	1846. Rainy days.	1846. Rain. ins.	1847. Rainy days.	1847. Rain ins.	Means. Rainy days.	Means. Rain. ins.	1855. Rain. ins.	1856. Rain. ins.	1857. Rain. ins.	1858. Rain. ins.	1859. Rain. ins.	1860. Rain. ins.	1861. Rain. ins.	1862. Rain. ins.	1863. Rain. ins.	Means. Rain. ins.
Jan. ..	26	23·32	20	24·25	27	35·82	24	27·80	22·30	15·87	7·95	32·50	17·96	5·63	14·22	13·58	6·86	15·21
Feb. ..	20	23·03	22	19·30	22	17·86	21	20·06	8·48	11·12	3·69	10·54	2·95	5·10	10·76	5·60	2·91	6·80
Mar. ..	19	12·84	15	7·08	22	17·44	19	12·45	9·25	8·45	4·88	7·84	12·18	2·11	10·80	8·71	10·19	8·27
April ..	15	8·06	15	5·48	20	8·36	17	7·30	2·90	0·70	3·43	2·66	1·66	0·54	0·67	1·54	2·40	1·83
May ..	6	1·60	10	2·96	4	1·22	7	1·93	0·19	0·99	1·94	0·68	0·94	3·53	0·48	1·52	1·56	1·31
June ..	4	1·09	6	3·24	4	0·82	5	1·72	—	0·17	1·80	—	4·45	0·68	0·71	0·17	—	0·89
July ..	12	1·28	11	1·40	6	0·87	9	1·18	—	0·37	0·11	1·59	—	—	2·53	1·68	0·45	0·75
Aug. ..	10	1·05	3	0·54	10	1·04	8	0·88	0·75	0·32	0·77	3·48	0·39	—	1·07	—	—	0·75
Sept. ..	13	3·88	10	3·45	3	0·40	9	2·57	0·30	0·44	5·53	1·56	1·31	3·91	3·31	0·12	2·55	2·11
Oct. ..	19	9·14	5	4·22	9	3·44	11	5.60	5·60	6·60	2·76	7·22	5·70	2·79	5·96	2·65	4·49	4·86
Nov. ..	19	27·	22	18·16	22	16·78	21	20·65	9·30	11·39	8·38	8·01	8·18	15·52	7·66	4·87	11·18	9·39
Dec. ..	20	12·46	28	16·64	28	27·72	25	18·94	13·35	29·99	16·81	11·38	13·04	16·89	21·85	18·88	8·98	16·80
Means	183	124·75	167	106·72	177	131·77	176	121·08	72·42	86·41	58·05	87·46	68·76	56·70	80·02	59·32	51·57	68·97
	176 days.	121·08 ins.							68·97 ins.									

The heaviest rains at GONGO SOCO were on

				h.	m.
1845, Jan. 13,	when	1·12 in.	fell in	1 :	0
17,	,,	0·72	,,	0 :	20
Feb. 22,	,,	3·92	,,	24 :	0
Nov, 13,	,,	1·04	,,	0 :	17
24,	,,	1·20	,,	0 :	25
25,	,,	2·24	,,	1 :	15
26,	,,	3·76	,,	24 :	0

				h.	m.
1846, Jan. 20,	when	5·24 ins.	fell in	10 :	30
Oct. 1,	,,	2·24	,,	1 :	15
29,	,,	0·66	,,	0 :	20
Dec. 1,	,,	6·30	,,	24 :	0

1846, Oct. 28, 3 p.m., a heavy fall of hail; thermometer in the shade at the time 78°.

				h.	m.
1847, Jan. 1,	when	7·50 ins.	fell in	10 :	0
1, 2,	,,	10·00	,,	36 :	0
18,	,,	6·68	,,	24 :	0
Oct. 1,	,,	2·24	,,	1 :	15

a Henwood, *London, Edinburgh, and Dublin Phil. Mag.*, XXVIII. p. 366; XXX. p. 364; XXXII. p. 425.

b J. N. Gordon, Esq., Resident Superintendent at *Morro Velho*, MSS.

sometimes alternates with a thick drizzle for eight or ten days in succession; saturating the soil, loading every leaf with moisture, and causing many landslips.*

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* The undermentioned effects of rain has been recorded at *Gongo Soco*:—

On the 2nd of December, 1827, a shower, which lasted but a quarter of an hour, washed so much rubbish from the mountain-side, that it filled great part of the ancient *(Talho Aberto,—Table VIII.* column 15) open-work, and covered, to a depth of several feet, the mouths of both *adits* in the valley.

Lyon, *Reports of the Imperial Brazilian Mining Association,* iv. p. 36.

On the 22nd of November, 1830, a mass of earth and stones some ten or twelve feet in thickness—loosened from the higher and steeper slopes by thirty-six hours of heavy and continuous rain—slid suddenly into the low grounds;—sweeping before it trees, underwood, and two cars in course of being loaded on the mountain;—burying heaps of ore, many surface-works, and one of the water-wheels;—injuring several shallow parts of the mine; and filling the deeper *(levels)* galleries.

Skerrett, Jennings, Hambly, Prideaux, & Harris, *Ibid,* x. pp. 42, 64.

On the 8th of December, 1831, a hillock of ancient *débris*, which had been softened by the rain, slipped suddenly down one of the eastern glens; stopping one of the water-wheels, choking the *adit*, and covering two or three acres of the valley, some twelve or fifteen feet with stones, trees, brushwood, and mud; but, happily, neither touching the principal surface-works nor entering the mine. A yoke of oxen having become entangled, were saved with some difficulty, as most of the people had already left work.—Skerrett, *Ibid,* xii. p. 43 *(Abstract).*

Notwithstanding much precaution, the *(Regos)* water-courses—which at *Gongo Soco* extend more than twenty miles—suffer great damage during the rains.

Ibid, Passim.

The *(Termes fatale, L.)* ants, which are exceedingly numerous, open from their large, hard, earthen nests, narrow underground passages, of great length, in all directions. These often penetrate and so weaken the banks that they give way; when the streams, as they escape, bear with them to the rivers quantities of earth and stones.

In the *(Campos)* pastures near *Gongo Soco* a colony of ants had built themselves nests, some three or four feet in breadth and height, and had covered them with waterproof clay. About one hundred yards off a beautiful garden, belonging to the Chief Commissioner, was so watered that each bed formed, as it were, a separate island. The intervening space,—though traversed by a rivulet —was, however, thoroughly tunnelled by these mischievous neighbours. They neither entered the houses, nor worked during the day; but—opening after sunset the passages, perhaps previously, made beneath the water—they frequently stripped an entire bed of all vegetation, save the stems of herbs and the branches of trees, in a single night. This havoc, however, was not quite indiscriminate; for they left cucumbers, lettuces, pine-apples, and sometimes orange and coffee trees uninjured; but invariably destroyed every rose-tree and cabbage within

These, however, are often arrested in their descent; and of those which reach the grassy lowlands, small portions only find their way to the rivers.

Where a want of vegetation subjects the rocks to direct atmospheric influence,* they are rapidly and continually disintegrated.† The portions degraded, with the auriferous beds they contain, and such small quantities of ancient *cascalho* as yet remain within reach, are from time to time swept into the rivers by the rain. Very different quantities, however, fall within short distances.

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reach. On different occasions—smiths' bellows were used for forcing the smoke of sulphur and charcoal into the holes;—for weeks in succession water flowed through the nests,—meanwhile the eggs were dug out and destroyed, by cart-loads at a time; these, and other, means, however, merely checked—but failed to extirpate—the enemy.

* In the dry-season every available rill was required to drive the *stamps* at *Gongo Soco* from fifty-five to sixty-five blows per minute (*Table IX.* Note *l*). During the day, however, evaporation from the (*Regos*) water-courses (*Ante*, p. 350, Note *) caused them to work—at times as much as one blow per minute —more slowly than they worked at night.

† Near Brumado the works of Captain José Alvarez, are carried on in a cleft opened—apparently by natural causes—some twenty feet deep, near the summit of a mountain of decomposed granite, which may be truly called auriferous; * * * for specimens of the earth, from the roots of the grass to the bottom of the *lavra*, all contained gold.—Mawe, *Travels in Brazil*, p. 374.

"Chaque jour le Rhin travaille à modifier son lit en corrodant certaines parties "de ses rives; de là la formation de ces nombreaux bancs de gravier et îles, "entre lesquels il se partage. * * *

"Tout le lit est aurifère, à peu d'exceptions près; mais cet or, chaque fois qu'il "est transporté par l'eau avec les cailloux au milieu desquels il est disséminé, "va se concentrer spécialement dans certaines positions qu'il importe de savoir "reconnaître *à priori*. * * *

"Les bancs nommés *Goldgründe*, auxquels l'orpailleur doit particulièrement "s'adresser, sont ceux formés à quelque distance à l'aval d'une rive ou d'une "île de gravier corrodée par le courant; ces bancs résultent par conséquent d'un "transport du gravier, tantôt sur quelques mètres seulement, tantôt sur 1,000 "ou 1,500 mètres de distance. C'est dans une zone étroite qui termine les "bancs vers l'amont, que pour abréger on peut appeler leur *tête*, que se trouvent "particulièrement accumulées les paillettes, presque toujours au milieu de gros

Gongo Soco,* at the foot of a high, wooded *Serra*, near a great tributary of the Rio Doce, and *Morro Velho* † in an equally mountainous, but an unwooded, region, of much the same elevation, on the upper waters of the Rio das Velhas, some twenty miles distant, afford example; for

	inches.	
three years' observations show an average annual fall of ..	121·08 at the former ;‡	
whereas		
nine years' „ „ „ but	68·97 at the latter.‡	

Great quantities of gravel, sand, and mud are also carried to the rivers by the water in which ore is treated at the mines.

"cailloux; toutefois cette richesse exceptionnelle ne s'étend qu'à une faible "profondeur qui ne dépasse guère 15 centimètres. * * *

"Les digues artificielles entre lesquelles coule le Rhin sur une partie de son "cours, au-dessous de Kehl, sont entaillées par des coupures, ou *passes*, qui sont "destinées à donner passage aux hautes eaux; afin qu'elles aillent déposer des "ensablements au delà de ses digues. Les atterrissements ainsi formés derriére "les digues par un courant latéral renferment aussi des parties riches au milieu "du gros gravier. * * *

"Les bancs qui se forment au milieu du fleuve loin le leur point de départ sont "en général peu riches.

"Dans les bancs les plus pauvres, dont on essaye la teneur sur une grande "nombre de points, on trouve cependant aussi, en dehors des positions qui vien- "nent d'être signalées, des zones étroites et allongées de gravier riche; * * * "ainsi il n'est pas rare de rencontrer de ces zones riches au pied des talus ter- "minaux qui limitent un banc à l'aval. * * *

"Jamais je n'ai trouvé la moindre trace d'or dans le sable fin privé de cailloux "que le Rhin dépose encore journellement dans ses crues. On ne rencontre "même dans ce sable fin que des traces de fer titané et du quarz rose, qui "accompagne toujours l'or.

"Quelle que soit leur position dans la fleuve, les paillettes d'or sont associées "à des cailloux, dont la grosseur est en général en rapport avec la dimension "des paillettes qu'ils accompagnent. La résidu du lavage contient toujours du "fer titané, dont la quantité est proportionnelle à la quantité d'or."

DAUBRÉE, *Annales des Mines*, 4me Série, x. pp. 6, 13, 14.

* *Ante*, pp. 291—6.

† *Ibid*, p. 184.

‡ *Ibid*, p. 349.

The refuse of several open-works on the *Serra* of Antonio Pereira accumulates at the foot of the slope throughout the dry season: when—as in the *Bhabur* of Kumaon *—the water by which it is conveyed, sinks through the shingle; but—gliding along the rock beneath,—reappears at a lower level. During the rains, however, this deposit is swept down the valley; where it has raised the bed of the brook,—a tributary of the Gualaxo,—at least ten feet within fifty years.†

All *stamped ore* is carried from beneath the *heads.*—by water admitted on purpose—down long *(Canoäs)* inclined-planes, on which cured-hides and strips of baize are carefully laid. In the upper of these, rough grains and threads of gold are entangled; whilst further and further down, ore—more or less rich—

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* *Ante*, pp. 42—4.

† Captain Joaõ Pereira de Azevedo, MSS.

The refuse of several china-clay works encroach, in like manner, on the valley near St. Austell (1865).

The head streams of the Fal flow through Tregoss moor, where there are many tin stream-works; from which great quantities of matter are constantly washing into the river, and are carried down into the creek below Tregoney. The navigation has been destroyed for more than two miles, and the injury is rapidly extending. * * *

Restrongett creek formerly extended much farther up Carnon valley, than it now extends, but the upper part of the navigation has been choked by gravel and silt from the mines. * * * By the constant accession of such matter, the bed of the whole creek, except the anchorage in Restrongett pool, is now above the level of low-water at spring-tides.—

THOMAS, *History of Falmouth*, pp. 31, 48.

About the middle of the last century * * * sand for manure was brought by barges as high as Dunstan's mills [more than a mile above the present limit of navigation].—FRANCIS, *Gwennap*, p. 8, Note.

"In 1851, West and South Caradon Mines paid a large compensation to the "landowners in the lower part of the Seaton Valley, for injuries occasioned by" sand and mud from the works.—ALLEN, *History of Liskeard*, p. 398, Note.

subsides, somewhat in the order of its specific gravity.* The portions escaping scarcely shew a trace of gold at first; but trituration by the rippling brooks † into which they fall,—separating light fragments of *vein-stone*,—lays bare the richer particles enclosed; within short distances, therefore, certain of the better parts are deposited ‡ in the beds and at the sides of streams; whence they are sometimes gathered, and a second time submitted to like treatment.

The ore which escaped from *Gongo Soco* accumulated at Taboleiro, about a mile from the principal works; where—on being once more *stamped* and *dressed* §—it yielded, on an average, a *(Troy)* pound of gold per month. For more than thirty years some fifty-five thousand tons of *stamped* iron-ore and talcose mud were annually discharged from this mine into the Socorro river; yet *Mandí* || were caught in great

* *Table VII.* Notes *h—t; Table IX.* Note *m* 1—6.

† At *Gongo Soco* the horses and mules preferred the rill in which *Jacotinga* had been *stamped*, to water of greater purity.

‡ A small stream which rises amongst the hills south of Camborne, is—in various parts of its course to the sea near Gwithian—used for *(dressing)* washing the produce of *Condurrow, Dolcoath,* and *Wheal Crofty;* but from each mine it carries off, in suspension, small quantities of tin-ore, still adhering to its matrix. The separation, which *stamping* and other processes had failed to accomplish, is, however, gradually effected by the action of running water; minute portions of ore are therefore collected in lower parts of the stream, by appliances exactly similar to those which had been inefficient to arrest them above.—Captain Charles Thomas, MSS.

§ We have minutely examined the tank at Taboleiro, and find that the upper portions of its contents consist of fine *Jacotinga*, sand, and slime, the lower of rough *Jacotinga* only; the former we propose to pass over *Concentration-strêkes (Table IX.* Note *m*—6), the latter to stamp; we expect this system will answer very well.— von Helmreichen, Harris, Collins, Blamey, & Pengilly, *Reports of the Imperial Brazilian Mining Association*, xxx. p. 87.

|| " *Mandí*,—one of the *Siluridæ*, perhaps a species of *Mystus;* from a foot and

numbers. At *Agoa Quente* also, small *Traíra** throve in water which—reaching the *adit* at temperatures varying, in different parts of the mine, from 81°·9 to 96°·5†—was fouled with similar impurities.

At *Morro Velho,* in like manner, the *stamped-ore* which passes from the *Canöas* in suspension is collected on the *(Praia)* margin of a neighbouring stream, where it is again *stamped* and conducted over hides and baize. From 1856 to 1863,—1,365·25 lbs. (*Troy*) of gold were here obtained,‡ which, but for these repeated processes, must have been lost. In the last twenty-seven years more than one million five hundred thousand tons of pyritous, argillaceous, and quartzose sand and slime have been washed from this mine into the Rio das Velhas; nevertheless *Surubím,*§ weighing ten or twelve pounds, are still taken near Sabará.

As the bed of every river is, with more or less regularity and abundance, replenished from each

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" a half to two feet long, with no apparent scales, and long barbecels proceding " backward from its mouth. It keeps near the bottom of the river, is taken " by the hook, and considered one of the best fish it produces."

Gardner, *Travels in Brazil,* p. 416.

* " *Traíra.*—Also about two feet long and rather slender, it takes the bait " and is much estemed."—*Ibid,* p. 416.

† *Postea*—Appendix.

‡ Symons, *Reports of the Saint John d'el Rey Company,* xxvii. p. 40; xxviii. p. 47; xxix. p. 43; xxx. p. 43; xxxi. p. 48; xxxii. p. 60. Dietzsch, *Ibid,* xxxiii. p. 50; xxxiv. p. 49.

§ " *Surubim.*—This fish, which is a species of sturgeon, often reaches the " length of six feet. It is taken most commonly in nets, but sometimes also, " especially by the Indians, by being shot at with an arrow, to which a strong cord " is attached. The flesh of this species dried, is that principally sold in the " Sertaõ " (high table-land); " I have frequently tasted it, and found it excel- " lent."—Gardner, *Travels in Brazil,* p. 415.

formation within the district it drains; the metallic, as well as the earthy, portions of these deposits, in various streams,—and sometimes even in distant parts of the same stream,—present characteristic differences.

Crystals, dendritic flakes,* thin scales, *nuggets*, threads, and grains of gold are thus mingled with the other ingredients; but the largest of them rarely exceed a quarter of an inch in diameter, and the smallest are microscopic.† Trifling quantities occur on the hard, gravelly, shallows, where a few spangles are now and then found and swallowed by water-fowl; ‡ but the greatest part is scattered through the sand and silt.

The gravel and coarse sand, when collected, are

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* Rounded grains and *nuggets* are mixed—with crystals of gold at Ballarat,—with dendritic gold at Mount Alexander, — and with both at Mc Ivor river Victoria), Australia.—Stephen, *Quarterly Journal of the Geological Society of London*, x. p. 306—8.

† " L'or ne se trouve jamais le gravier du Rhin en pépites ou en petits grains ; " il est toujours sous forme de paillettes très-minces, à contours arrondis, dont " le diamètre n'excède pas un millimètre " (0·03937 inch) " et est souvent " beaucoup moindre. * * * La surface de ces paillettes examinée au micro- " scope présente une multitude de petites aspérités assez réguliéres. * * * Le " poids moyen d'une paillette est de 0·0562 milligramme " (0 000867 grain).
Daubrée, *Annales des Mines*, 4me Série, x. p. 21.

‡ The late Mr. Fitzpatrick of *Gongo Soco* presented me with a small quantity of quartzose and ferruginous gravel, mixed with minute scales—weighing some fifteen or twenty grains—of gold; which his cook had found in the gizzard of a Muscovy duck; brought, a few days previously, from Brumado on the Santa Barbara river.

The crop of a second duck, from the same place, contained similar gravel but a smaller proportion of gold.
Edinburgh New Phil. Journal, l. p. 62.

" The cook of a Government officer at Galle recently brought to him a ruby " about the size of a small pea, which he had taken from the crop of a fowl."
Emmerson Tennent, *Ceylon*, i. p. 34.

stirred — until they become suspended — in small streams; which are passed over *(Canoäs)* inclined-planes, laid with baize, as at the *stamps*.* The richer and heavier parts,—subsiding first,—are then washed in the *batêa*,† until the gold is separated from its earthy accompaniments. The fine sand and mud are treated in the *batêa* only; the *(Faiscador)* washer standing—often nearly to his middle—in the stream, whilst he scrapes the ore from its bed. To protect himself from the sun and rain,—which occasionally alternate several times a day during the hot season,—he uses a coarsely platted covering of long grass; ‡ which—reaching from head to waist—serves as both hood and cape.

Great numbers of poor freemen earn a scanty livelihood § by thus separating the gold from the detritus; and many *(Roçeiros)* small farmers employ their slaves in the same manner, when field-work is slack.‖

The proportion of gold obtained, from the beds of

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* Mawe, *Travels in Brazil*, p. 266. von Spix und von Martius, *Reise in Brasilien*, I. p. 340. von Eschwege, *Pluto Brasiliensis*, p. 256. de Saint-Hilaire, *Voyage dans les Provinces de Rio de Janeiro et de Minas Geraes*, I. p. 250. Gardner, *Travels in Brazil*, p. 497. *Ante*, p. 353: *Tables—VII.* Note *k*; *IX*. Note *m*—3.

† Mawe, *Travels in Brazil*, p. 109. von Spix und von Martius, *Reise in Brasilien*, I. p. 340. Gardner, *Travels in Brazil*, p. 510. *Table IX.* Note *l*.

‡ "Les nègres se préservent de la pluie avec des espèces de manteaux assez "pittoresques, faits avec les feuilles très longues et fort sèches d'une Graminée "ou Cypéracée, que l'on appelle *capim mumbéca*."—DE SAINT-HILAIRE, *Second Voyage dans l'Intérieur du Brésil*, I. p. 189.

§ *Ante*, pp. 224, 283, 301.

‖ *Ibid*, p. 299.

"Slaves are allowed to work on their own account on Sundays and holidays."
GARDNER, *Travels in Brazil*, p. 465.

Ante, p. 301, Note †.

existing rivers,* has never been ascertained; but in 1849 it was estimated that, on an average, each *(Faiscador)* washer collected from four to five (4·684) grains of gold; and thus earned about (one *pataca*—320 *reis*) eight pence per day.†

The (*Faiscador*) gold-washer pays no (*dues*) Royalty to the landowner.

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*After the ancient detritus of the Rhine had been abraded, transported, and redeposited by the stream, it yielded the undermentioned proportions of gold;—

Varieties of (ore) sand.	Proportions of gold.
First quality	0·000000562.
Second ,, ...	0·000000243.
Third ,, average wrought	0·000000132.
Fourth ,, poorest ,, ...	0·000000120.
Fifth ,, unwrought	0·000000008.

Daubrée, *Annales des Mines*, 4me Série, x. pp. 16, 28.

† In that year the gold of *Antonio Pereiro* (23 *carats* 3·5 *grains* fine) was sold at (3,500 *reis* per *oitava* of 55·33 *grains*) £40 : 19 : 10 per lb. *Troy*.

During 1814 the rivers of Minas Geraës afforded employment to

3876 freemen and
1871 slaves } 5747 persons;

	oitavas	*lbs.*		*per lb.*		
who extracted	(115,321·25)	1,107·768	of gold, worth	(at £40 : 19 : 10)	about	£45,418
each (*Faiscador*) workman therefore obtained, on an average	(20·06)	0·1927	,, , ,,	,,	,,	[per ann. 7 : 18 : 0
and reckoning 300 working days in the year, ,,	*oitava* (0·06)	3·7 grains	,, , ,,	,,	,,	[per day. 0 : 0 : 6⅓

von Eschwege, *Pluto Brasiliensis, Tabellarische Uebersicht aller Goldlavras jeden Districts in Minas Geraës*, p. xxi.

The Rhenish *(Orpailleur)* gold-washer treats about (four cubic *mètres*,—one hundred and forty-one cubic feet) eleven tons and a quarter of sand; earning —according to the quality of the deposit he works—now and then from eight to twelve shillings, but seldom more than twenty, and sometimes less than ten, pence, per day. Some five hundred persons engage in this pursuit at intervals; but—as most of them are either husbandmen, boatmen, or fishermen, on occasion—the entire proceeds of their labour range only from (40,000 to 45,000 *francs)* sixteen to eighteen hundred pounds a year.

Daubrée, *Annales des Mines*, 4me Série, x. pp. 12, 23, 24 (Abstract).

Whitney, *Metallic Wealth of the United States*, p. 94. *Ante*, pp. 245—8, Notes.

The deep-yellow grains and microscopic crystals of gold * collected in the Gualaxo, are akin to those of Antonio Pereira,† near the source of its principal tributary;—the paler flakes, small *nuggets*, and crystalline granules found in the Periçicába have a family likeness—both in hue and in alloy—to the gold obtained—where its head-waters rise,—amongst the talcose and quartzose rocks of the Caraça; ‡—and the dark-coloured gold of the Socorro river—like that of *Gongo Soco* § in its vicinity,—is associated with copper, silver and palladium. But it is needless to lengthen this list; for the metallic as well as the earthy ingredients, in the bed of every river, resemble those of adjoining mountains.|| Detrital-gold—like *stream* tin-ore,¶–however, is always of better quality,** and invariably fetches a higher price, than mine-gold of the same neighbourhood.

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* Henwood, *Edinburgh New Phil. Journal*, L. p. 63.

† *Ante*, pp. 214, 304; *Table* X. column 17.

‡ *Ante*, pp. 177, 181, 236, 241.

§ *Ibid*, p. 286; *Tables*,—*IX*. column 49, *X*. column 17.

|| *Ante*, p. 355.

¶ "*Stream Tin*—consists of detached fragments, or of crystals of tin."
PHILLIPS, *Mineralogy* (3rd Edit.), p. 253.

In "an interesting group of fine crystals of gold, interlacing an hexagonal "quartz-crystal" from Mc Ivor river (Australia), such of the edges of the gold "and quartz crystals as have been exposed to the contact of rough bodies are "rubbed and destroyed, whilst the edges of the crystals which have been pro- "tected by surrounding crystals are as perfect and sharp as when formed by "nature."—STEPHEN, *Quarterly Journal of the Geological Society*, x. p. 307.

** "The quality of the tin-ore found in stream-works is very much superior "to that obtained from veins at small depths."
HENWOOD, *Cornwall Geol. Trans.*, IV. p. 65.

The following analyses of detrital and mine gold from New Granada, are recorded by M. Boussingault.

Although gold was obtained from this region in 1599,* and—if tradition be credited—for sometime bartered by the Indians † with the earlier settlers; it

Localities.	Detrital-gold. Proportions of		Mine-gold. Proportions of	
	Gold.	Silver.	Gold.	Silver.
Bucaramango	0·980	0 020		
Giron	0·919	0·081		
Lavega	0·821	0·179		
Quiebralomo	....	....	0·919	0·081
Marmato	....	....	0·744	0·256
Means	0·907	0·093	0·831	0·169

Annales des Mines, 3me Série, I. p. 446.

"On pourrait aussi admettre, au moins pour l'or natif du Chili, qu'en général "l'or menu est d'un titre plus élevé que l'or qui se trouve en gros grains et en "pépites."—Domeyko, *Ibid*, 4me Série, VI. p. 169.

"On croit généralement dans l'Oural et à Saint-Pétersbourg que l'or des "sables est ordinairement plus riche en or que celui des filons. M. Gustave "Rose a été conduit par ses analyses à un résultat contraire : celles-ci indiquent "moyennement, dans l'or des filons 0·0791 d'argent
" sables 0·0897 " ."

Ibid, 3me Série, V. p. 169.

"Il y a en moyenne dans l'or du Rhin
0·93400 d'or,
0·06600 d'argent,
"et, après l'analyse de M. Doebereiner, 0·00069 de platine."

Daubrée, *Ibid*, 4me Série, X. p. 22.

"I have found by observation" (in Bolivia) "that the gold is purer in pro-"portion as it is further from its source."

Forbes, *London, Edin., & Dublin Phil. Mag.* (4th Series), XXIX. p. 133.

* "In the last year of the sixteenth century, D. Francisco de Souza * * * "sent to Philip III. a rosary composed of native grains of gold."

Southey, *History of Brazil*, III. p. 40.

† It is still believed in the neighbourhood, that the first explorers found them fishing the Rio das Velhas with golden hooks.

was not until 1695 that systematic explorers discovered it *in place.**

A code, promulgated in 1618, regulated the disposal of all mineral-lands, but reserved to the Crown a proportion of their produce.†

For a considerable period this Royalty was nominally twenty per cent.; but the annual receipts—which often fell short of the captures from smugglers‡—were never as much as (four *arrobas)* 157·40 *Troy* lbs. of gold.§ After some time stipulated quantities—at first (thirty)‖ 1180·5, but subsequently from (twenty-five to thirty-seven, *arrobas)*¶ 983·75 to 1455·95 lbs. a year—were substituted for the previous *(quinto)* per centage. Meanwhile a tax of (twelve *oitavas)* 1·383 oz. of gold had been levied on each workman employed in mining; ** but the arrangement had proved so unsatisfactory, that, within a twelvemonth,†† the

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* "The first gold which is certainly known to have been produced from this "district was a sample of three *oitavas*" (0·346 oz. *Troy*) "presented in 1695 to "the *Capitam Mor* of Espirito Santo by Antonio Rodriguez Arzam, a native of "the town of Taboate."—SOUTHEY, *Brazil*, III. p. 49.

† *Ibid*, pp. 41—5. Mawe, *Travels in Brazil*, p. 247. von Eschwege, *Pluto Brasiliensis*, pp. 102—15; *Memorias Historicas de Minas Geraes*, p. 167.

‡ von Eschwege, *Pluto Brasiliensis*, p. 280.

§ *Ibid*, p. 280.

"Na era de 1711 se vio praticado o invento da Roda para facilitar o trabalho "mineral, de que foi autor am clerigo vulgarmente conhecido com o nome de "Bonina."—*Memorias Historicas de Minas Geraes*, p. 175,

‖ Southey, *Brazil*, III. p. 150. von Eschwege, *Pluto Brasiliensis*, pp. 179-280.

¶ von Eschwege, *Pluto Brasiliensis*, pp. 179—80, 280.

** "Instead of taking a fifth at the Smelting-house a poll tax of not less "than twelve *oitavas* was to be paid for every negro employed in mining."
SOUTHEY, *Brazil*, III. p. 168.

†† "The experience of a single year proved this to be as little advantageous to

commutation of (thirty *arrobas**) 1180·5 lbs. was re-established. After a few years, however, this was replaced by a duty of twelve per cent.;† which—as gold became more abundant—was, in turn, compounded for (one hundred *arrobas*) 3935 lbs. per annum.‡ At length every one employed in the mines was—without regard to sex or condition—annually assessed at (four *oitavas* and a half) 0·519 oz. of gold;§ a disposition eventually succeeded by the original (*quinto*) duty of twenty per cent.|| For several years

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"the Treasury, as it was agreeable to the people, and the Governor therefore "was instructed again to accept the thirty *arrobas*" of gold.

Southey, *Brazil*, iii. p. 168. *Memorias Historicas*, p. 168.

* The Municipal bodies collected the commutation, "and the richest settlers "raised it by an assessment amongst themselves, according to the number of "their negroes."—Southey, *Brazil*, iii. p. 156.

† *Ibid*, p. 265. von Eschwege, *Pluto Brasiliensis*, p. 180.

‡ "The Municipal *Camaras* engaged to make up to the Treasury the yearly "quantity of one hundred *arrobas*, * * * if the fifths" (*dues*) "should fall "short of that amount. But in apportioning this impost great injustice was "committed. Some *Camaras* were taxed more heavily than others; and they "in their turn laid on the burden unequally amongst the people within their "jurisdiction, oppressing those who possessed no influence, and favouring the" (rich) "*Poderosos*. The Court in consequence instructed the Governor to make "the assessment himself, and by no means to leave it to the *Camaras*."

Southey, *Brazil*, iii. p. 267.

von Eschwege, *Pluto Brasiliensis*, p. 180; *Memorias Historicas*, p. 171.

§ "The proposed tax was an impost of two *oitavas* and twelve *vinteins*" (0·259 oz.) "of gold every half year, upon every slave male or female. * * * "Free persons of European birth or extraction" as well as "free negroes and "emancipated people of colour who possessed no slaves, but worked themselves "in agricultural or mining employments * * * were liable to the tax."

Southey, *Brazil*, iii. p. 271.

Memorias Historicas, p. 172.

The inhabitants of Minas Geraës on whom taxes were assessed

in 1742 were .... 1771 free .... 186,868 slaves;
1743 „ .... 1759 „ .... 185,759 „ .

von Eschwege, *Pluto Brasiliensis*, p. 286.

|| "Com o dia 1° do mez de Agosto de 1751 principiou o observancia do quinto "restabelecido, entrando d'ahi a correr a totalidade annual das 100 arrobas de

the receipts averaged more than the (one hundred *arrobas)* 3935 lbs. guaranteed by the miners; * but—thenceforward slowly yet continually diminishing—they amounted in 1820 to (two *arrobas*) 78·70 lbs. only.† For a time the inhabitants were charged five,—whilst foreigners paid twenty-five,—per cent.; ‡ but—after many trifling changes §—the *Dues (Provincial Duties)* on gold were abolished.

When the Royalty *(quinto)* was established, the miner could not legally dispose of his gold-dust until he had obtained a *(Guia)* certificate from the authorities; ‖ but in after years the King's dues were

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" ouro, que os povos se obrigáraõ a segurar á real coroa, tomando sobre si o " encargo de completa-las por via de derrama."—*Memorias Historicas*, p. 173.

Southey, *Brazil*, III. p. 592; von Eschwege, *Pluto Brasiliensis*, p. 180.

* " For about sixteen years the average of the *fifths* considerably exceeded the " hundred *arrobas* " (3935 lbs.); " but when the trade was thrown open * * * " they began immediately to decline, and the average upon eleven years fell from " one hundred and nine *arrobas* " (4289·15 lbs.) " to eighty-six " (3384·10 lbs.)

SOUTHEY, *Brazil*, III. p. 593.

von Eschwege, *Pluto Brasiliensis*, p. 282.

† *Ibid*, p. 282.

‡ *Reports of the Imperial Brazilian Mining Association*, I.—XXIV.

§ *Ibid*, XXIX. p. 7; LV. p. 10. *Reports of the Saint John d'el Rey Company*, XXVII. p. 12.

‖ " Para a boa arecadaçaõ dos quintos que pertencem a Fazenda todo o ouro que " sahir das minas sahirà com registro, para o que o Superintendente terà hum " livro por elle rubricado, e assignado em que pelo seu Escrivaõ se farà termo, " com declaraçao da pessoa que registra o ouro, dos marcos, ou oitavas que " registra, da officina dos quintos para onde o leva a quintar; do dia, mez, e " anno, em que faz o dito registro, o qual termo assignará o dito Superintendente " com a tal pessoa que registrar o ouro; e do dito termo lhe mandarà o dito " Superintendente dar huma guia por elle assignada dirigida para a officina dos " quintos que tiver declarado no dito termo, na qual hirà declarado o pezo do " ouro que leva de que hade pagar os quintos."—*Regimento dos Superintendentes, Guardas-Mores, e officiaes deputatos para as Minas do Ouro.* Lisboa a 19 de Abril de 1702.

Southey, *Brazil*, III. p. 62. von Eschwege, *Pluto Brasiliensis*, p. 127.

taken at *(Casas de Fundicaõ)* Smelting-houses in the several *(Comarcas)* districts,* where specially appointed officers cast the dust into bars, which—on being inscribed with their respective weights and *(Tocas)* qualities and stamped with the Royal arms—were ready for the market; for some time before this impost was abolished, however, the ancient mode of collection had been resumed.† But, in spite of every precaution,‡

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* "Em virtude do Decrêto de 4 de Fevereiro de 1719, as ordens de 8, e o "alvará de 11 do mesmo mez e anno, saõ establecidas nos districtos mineraes, e "onde parecesse mais commodo, algumas casas de fundiçaõ a fim de se reduzir "o ouro em pó a barras, marcando-se estas com as armas reaes, e contra-"marcando-se, com declaraçaõ do seu peso, quilates do ouro, e do anno em que "se fundiaõ."—*Memorias Historicas*, p. 168.

Southey, *Brazil,* III. p. 246.

† *Reports of the Imperial Brazilian Mining Association,* XII. (1832) p. 93. *Table IX.* Note *r.*

‡ "Not only were all foreigners forbidden to enter the country, but no person "whatever might embark for it, unless he were appointed to an office there; he "might then take with him only such servants as might be deemed necessary, "and all these were to be Portugueze. Portugueze going on business must have "passports; and of the Clergy, none were allowed to embark except Bishops, "Missionaries, Prelates, and Religioners already established in that state."
Southey, *Brazil,* III. p. 254.

"Travellers upon entering the province exchanged their coin for gold dust, "and upon leaving it were to exchange their gold dust for coin. Gold dust was "the only circulating medium in Minas Geraes."—*Ibid* p. 594.

Memorias Historicas, p. 166.

"Nothing but cattle might be brought" to the mining district by land. The "drovers were required "to notify their arrival, and specify what number of head "they imported. * * * They were also to inform the officers of Government "the prices they obtained in order that if the gold wherewith they were paid "had not previously been *fifthed,* the Treasury might exact its due. * * * It "was required that all other commodities should be shipt for the Rio, and intro-"duced by way either of Taboate or S. Paulo."—Southey, *Brazil,* III. p. 62.

Regimento dos Superintendentes, Guardas-Mores, e Officiaes Deputados para as Minas de Ouro (1702).

"Laws against making new and bye roads were enacted, and the penalties

smuggling—which commenced with the discovery of gold *—increased to an enormous extent; † and was at last carried on ‡ with scarce an attempt at concealment.

" from time to time enforced; but it was impossible to guard so wide a country."
SOUTHEY, *Brazil*, III. pp. 65, 594.

"No goldsmith was to be tolerated, nor any settler suffered to remain" in the Province "who had a slave capable of exercising this forbidden craft."
Ibid, pp. 62, 264, 594.

Regimento dos Superintendente, Guardas-Mores, e Officiaes Deputados (1702).

" All Religioners, of what family soever, were to be banished from the Mines. " Their property was to be sequestered, unless they removed in eight days; and " if they had none they were * * * sent prisoners to the Rio; and from thence " to Portugal."—SOUTHEY, *Brazil*, III. p. 147.

" Private letters were intercepted and opened, under pretext of discovering " what persons were engaged in the clandestine exportation of gold."
Ibid, p. 253.

* von Eschwege, *Pluto Brasiliensis*, p. 280.

† " The greater the produce the greater was the contraband trade."
SOUTHEY, *Brazil*, III. p. 157.

‡ " Notwithstanding strict regulations, a considerable quantity of the precious " metal in its original state found its way to Rio de Janeiro, Bahia, and other " ports, clandestinely, without paying the Royal fifth."
MAWE, *Travels in Brazil*, p. 247.

The stipulation that (one hundred *arrobas)* 3935 lbs. of gold a year should be paid as Royalty, did not prevent contraband practices.
SOUTHEY, *Brazil*, III. pp. 157, 268.

" The traders into whose hands the gold passed debased it so greatly, that if " it found its way to the Mint, there was usually a loss of ten or twelve per cent. " upon the assay. * * * The treasurers were to be careful that they received " good gold, without any mixture or deceit, and not of low quality; they were " therefore not to accept in payment the gold of Borda do Campo, Congonhas de " Sabará, or Pitanguí, except from persons residing, or having slaves at work " there."—*Ibid*, pp. 273, 594.

" The goldsmiths were the great agents and allies of the miners in their per- " petual endeavours to avoid the payment of the *fifths*. It was not possible to " ascertain whether wrought gold had been *fifthed* or not; and they made it up " into trinkets, and pieces of such rude workmanship as evidently to betray the " purpose for which they had been fabricated."—*Ibid*, pp. 264, 595.

" When once the gold reached the great cities, goldsmiths were ready to cast " it into ingots and set upon it the false stamp.—*Ibid*, p. 595.

The Baron von Eschwege—whose official connexion with the mines* gave him access to authentic information,—recapitulates the annual receipts of Royalty from 1700 to 1820; † and thence deduces the produce of the Province. But, as divers modes of assessment prevailed at different times,‡ and as smuggling increased under every arrangement,§—his calculation was probably an insufficient one.

	lbs. Troy.
From 1700 to 1820 the quantity of gold, on which Royalty was paid,‖ has been estimated at	1,404,312
,, ,, taken from Smugglers,‖ amounted to	655
Forward	1,404,967

* Mr von Eschwege resides at Villa Rica as Colonel of the Engineers and Director of the gold-works.

von Spix and von Martius, *Travels in Brazil* (English Translation) II. p. 168.

† *Pluto Brasiliensis*, pp. 280—3.

‡ *Ante*, p. 361.

§ Southey, *Brazil*, III. pp. 268—71.

‖ Estimated quantities of gold obtained in Minas Geraës at different times.

Periods.	Gold: Taken from Smugglers. lbs. *Troy.*	Duty-paid. lbs. *Troy.*	Totals. lbs. *Troy.*
1700—1713	451·284	2,721·396	3,172·680
1714—1725	—	61,484·375	61,484·375
1725—1735	—	98,375·000	98,375·000
1735—1751	—	403,320·723	403,320·723
1751—1777	203·678	490,921·682	491,125·360
1777—1820	—	347,489·540	347,489·540
Totals....	654·962	1,404,312·716	1,404,967·678

From 1700 to 1820 the amount of *(quinto)* Royalty actually received was lbs. 280,862·592 of gold.—von Eschwege, *Pluto Brasiliensis*, p. 283.

" The commutation was collected until the average " of the fifths " fell below " ninety arrobas " (3541·5 lbs.); " but from the death of King Jozé " (in 1777), " at which time the decay of the mines became more and more rapid every year, " the arrears had been allowed to accumulate, till, in 1790, they amounted to " the tremendous sum of seven hundred *arrobas* " (27,545 lbs.).

Southey, *Brazil*, III. p. 680.

		lbs. Troy.
	Brought forward	1,404,967

Of the yield during forty following years the Records of Government make but little mention; and other sources of information are few.

In 1814 the entire produce of
Minas Geraës was........ (228,449 *oitavas)* 2,194·450 lbs; *
but of this the mines gave only (113,127 „) 1,086·687 „ .*

Soon afterwards, however, several of them became so prosperous † that they attracted the attention of foreign capitalists. In 1825 *Gongo Soco*—then one of the richest mines ‡ — was bought by the Imperial Brazilian Mining Association; and, shortly more than a dozen others were wrought by aid of British money and skill. Many of these, unfortunately, proved unproductive; and several were abandoned after brief—though costly—trials; so that at last *Morro Velho* alone was still worked by foreigners.

From 1825 to 1860 the mines belonging to English Companies § yielded about..	91,000
Forward......	1,495,967

* von Eschwege, *Pluto Brasiliensis; Tabellarische Uebersicht aller Goldlavras jeden Districts in der Provinz Minas Geraes, in Jahre* 1814, XXI.

† *Ante*, p. 216, Notes † ‡; *Table VIII.* column 15.

‡ " Within fifteen years a larger amount of *Duty* has been received from " *Gongo Soco*, than in twice that time from all the Province beside."

Sen. Manoel Teixeira de Souza, *Secretary of the Treasury at Ouro Preto* (1844).

				lbs.		
§ From 1825 to 1856	*Gongo Soco*	yielded	34,528	of gold.	*Table IX.* column 46.
„ 1833 „ 1846	*Cocaës*	„	557	„	*Ante*, p. 247.
„ 1835 „ 1860	*Morro Velho*	„	51,631	„	*Table VII.* column 26.
„ 1840 „ 1844	*Catta Branca*	„	3,167	„	*Ante*, p. 179.
„ 1844 „ 1846	*Catta Preta*	„	28	„	*Reports of the Imperial Brazilian Mining Association*, XXXVII.—XLII.
„ 1847 „ 1853	*Agoa Quente*	„	808	„	*Ante*, p. 235.
	Forward ..	lbs.	90,719	„	

Of those wrought by native proprietaries, a few have been, at intervals, very rich; * but in general their produce has materially declined.†

In 1814 the rivers afforded (115,321·25 *oitavas)* 1,107·768 lbs. of gold; ‡ but the gradual impoverishment of the mines whence their existing beds were in great measure derived,§ and the gleaning to which they were continually subject,|| had so much diminished

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	lbs.
Brought forward	90,719 of gold.
From 1820 to 1860 *Antonio Pereira*, *S. Joaõ d'el Rey*, *S. José*, *Mocaübas*, *Candonga*, *S. Vicente*, *Morro das Almas*, *Cuiabá*, *Emilia*, and *Conceiçaõ*, together, yielded about	1,000
Total .... (say) ..	91,719 lbs. *Troy*.

* During the years 1852,-3,-4, seven mines in the Municipality of *Itabira* afforded (253,479·25 *oitavas)* 2434·900 lbs.

of gold, which realized..............	(887,177,335 *reis*)	£99,807 : 9 : 0;
at a cost of...........................	(97,928,266 ,,)	11,016 : 18 : 8.
Thus leaving a profit of	(789,249,069 ,,)	£88,790 : 10 : 4

Extracto das informacões prestadas pelas Camaras e outras Autoridades da Provincia (1855).

† " *Marianna.*—Informa u Camara que os moradores do Forquim applicaõ-se " a agricultura * * * Este Districto está muito decadente por faltar a minera- " çaõ, que por muitos annos o sustentar. * * * O districto do Inficionado está " no mesmo estado que o do Forquim. * * * O Districto de Abre Campo tem " varios terreno mineraes, porem a populaçaõ em geral só cuida da cultura." * * *

S. José.—" Informa o Juiz Municipal, 1° que a mineraçaõ está quasi abandona- " do por falta de braços; 2° que os principaes estabelecimentos saõ de lavoura e " criaçaõ de gado vaccum." * * *

Caethé.—" Informa o Juiz Municipal que o estado da mineraçaõ * * * naõ " offerece vantagem pela falta de braços da qual se queixaõ os mineiros, e agri- " cultores."

Sabará.—" O estado da mineraçaõ é prospero em varios Districtos deste " Municipio." * * *

Ibid.

‡ von Eschwege, *Pluto Brasiliensis*, *Tabellarische Uebersicht aller Goldlavras jeden Districts in der Provinz Minas Geraes*, p. xxi. *Ante*, p. 358, Note †.

§ *Ante*, pp. 352—6. || *Ibid*, p. 357.

		lbs. Troy.
	Brought forward	1,495,967

their yield in 1860, that the best-informed resident merchants estimated the entire produce of the Province—except the only mine then wrought by strangers—at (140,000 *oitavas**) less than 1,350 lbs. a year.

From 1820 to 1860, therefore, the gold extracted by Brazilian speculators from their mines, and by *Faiscadores* from the rivers was probably about .... 80,000†

Thus from 1700 to 1860, Minas Geraës afforded (some) ...... lbs. 1,575,967‡

of gold. Of late years, however, no separate account of it was kept, either at the Provincial Treasury or at the National Mint;§ this result must, therefore, be regarded as but an approximation.

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* "Dr. Margal Jozé dos Santos and I agree in thinking that, exclusive of "*Morro Velho*, the quantity of gold raised in Minas Geraes at present, amounts "to only (140,000 *oitavas*) 1344·826 lbs. per annum."

Septimus Ollivant, Esq., of Ouro Preto, MSS. (1860).

"Le Brésil a donné en 1755, 6000 kilogrammes" (16,085·416 lbs. *Troy*) "d'or, "mais on n'estime guère maintenant qu'à 1000 kilogrammes" (2,680·903 lbs.) "environ le produit de ce pays."—Levy, *Description d'une collection de Minéraux, formée par M. H. Heuland*, ii. p. 318 (1838).

† "L'or qu'on extrait de divers groupes de terrains dans la province de Minas, "est a peu près dans les proportions suivantes. Sur 100 parties;

"Le groupe	alluvial	donne	005
,,	diluvial	,, ...	008
,,	traumateux.	,, ...	050
,,	quartzeau ..	,, ...	012
,,	micacique ..	,, ...	025
			100"

Claussen, *Bulletins de l'Académie Royale des Sciences de Bruxelles*, viii.—Ire Partie, p. 328.

‡ Henwood, *Edinburgh New Phil. Journal*, l. p, 62.

			lbs. Troy.
§ "From 1849 to 1859 ..	the gold coined and recoined at the Mint in Rio de Janeiro amounted to	(7,578,745 *oitavas*)	72,800·688
"During the financial year 1858—9......		(257,392 ,,)	2,472·482
"1st Jan. to 1st July, 1860	,, ,, ,,	about (13,000 ,,)	124·877

"Much of this consisted of *Sovreigns* and other foreign money; but what part "of the rest was obtained in the Country is unknown.

Regarding the quantity of gold smuggled out of the Province during so long a period, it is manifestly impossible to offer even a plausible conjecture; but it is supposed to have been at least one-fifth of the whole produce.*

As the mines became less prosperous and foreign capital was gradually withdrawn, the inhabitants improved their roads, and occasionally substituted wheeled-carriages for beasts of burden. Landowners who in times past had found work for their people as gold-washers or as miners, now employed them as husbandmen or as herdsmen ; and from unfrequented districts, of which the produce had hitherto been sold at home for less than the cost of its conveyance to market, neighbouring towns were supplied with corn and cattle.†

"A considerable quantity of gold-dust, brought down by Muleteers and Shop-
"keepers, is absorbed by the Jewellers."

John Morgan, Esq., of the British Legation at Rio de Janeiro, MSS. (1860).

* That one-fifth of all gold extracted from the Captaincy had been clandestinely exported, was considered a moderate computation.—Southey, *Brazil*, III. p. 820.

† "Até certo tempo eminentemente mineira e rica pela extracçaõ do ouro e do "diamante, cujos jazigos marcavaõ o berço e fixavaõ o assento de muitas povo-"acões importantes, hoje e de ha certo tempo, tornando-se muito contingente, e "pouco lucrativa essa extracçaõ, esta industria tem definhado e sofrido progres-"sivo abandono, dirigindo-se com preferencia a actividade dos habitantes da "Provincia para a lavoura, e criacaõ que encontraõ riquissimos recursos em seu "vasto e variado solo que já lhe tem dado riquezas muito superiores ás que lhe "deu sua primeira industria, e por certo afiançaõ uma prosperidade mais segura "e sempre crescente."—*Falla que á Assembléa Legislativa Provincial de Minas "Geraes dirigio no acto da abertura da Sessaõ de* 1859 o Dr. Joaquim Delfino Ribeiro da Luz, 1° Vice-Presidente da mesma Provincia.

Notices of Gold-Mines in Virginia.

At considerable distances south-east of the Appalachian chain,* an approximately parallel band of slate,† —which, in various parts of its north-easterly and south-westerly range from Canada to Georgia and Alabama, consists of talc,‡ mica,§ chlorite,|| felspar,¶ and siliceous matter ** in different proportions,—alternates, at intervals, with short and ill-defined beds of auriferous quartz.††

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* Maclure, *Transactions of the American Philosophical Society,* I. N.S. p. 10, *Pl. I.* Rogers, *American Journal of Science,* I. Second Series, p. 474; Reports of the British Association, IV. (1834) p. 2. Lyell, *Travels in North America,* II. First Series, *Pl. I.* Whitney, *Metallic Wealth of the United States,* p. 121.

† Hitchcock, *Address to the Association of American Geologists at Philadelphia, in* 1841, p. 11. Whitney, *Metallic Wealth of the United States,* p. 122.

‡ Dickson, del Rio, Millington, and Clemson, *Transactions of the Geological Society of Pennsylvania,* I. pp. 20, 147, 308. Rogers, *Geological Reconnoissance of Virginia* (1836) p. 68. Ansted, *Scenery, Science, and Art,* p. 288.

§ Rogers, *Geological Reconnoissance of Virginia,* p. 71. Silliman, *American Journal of Science,* XXXII. p. 99. Whitney, *Metallic Wealth of the United States,* p. 128.

|| Rogers, *Geological Reconnoissance of Virginia,* p. 68. Clemson, *Transactions of the Geological Society of Pennsylvania,* I. p. 309. Whitney, *Metallic Wealth of the United States,* p. 122. Ansted, *Scenery, Science, and Art,* pp. 288—9.

¶ Featherstonhaugh, *Excursion through the Slave States,* II. pp. 354—8.

** Rogers, *Geological Reconnoissance of Virginia,* p. 68; *Reports on the Geological Survey of Virginia* (1839), p. 47, (1840) p. 48. Whitney *Metallic Wealth of the United States,* p. 128. Ansted *Scenery, Science, and Art,* p. 289.

†† Olmsted, *American Journal of Science,* IX. p. 5. Mitchell, *Ibid,* XIII. p. 1. Dickson, del Rio, Millington, and Clemson, *Transactions of the Geological Society of Pennsylvania,* I. pp. 16, 147, 157, 159, 308. Rogers, *Geological Reconnoissance of Virginia,* pp. 66—70. Silliman, Smith, and Maury, *American Journal of Science,* XXXII. pp. 98, 130, 325. Rogers, *Report on the Geological Survey of Virginia* (1840), p. 49. Featherstonhaugh, *Excursion through the Slave States,* II. pp. 354—8. Mitchell, *Map of the Gold-region of Virginia* (Fredericksburg, 1849). Whitney, *Metallic Wealth of the United States,* p. 128. Ansted, *Scenery, Science, and Art,* pp. 283—93. Whitney, *Metallic Wealth of the United States,* pp. 114—34. Logan, *Geological Survey of Canada,* Report of Progress, 1850-1, p. 6. *Mining and Smelting Magazine,* V. p. 109.

Of this formation no part has, hitherto, been more productive, than that which traverses Virginia.

(*a.*) The *Chancellorsville* or *Grasty* gold-mines are situate some twenty-five miles west of Fredericksburg, in an undulating—rather than a hilly—part of Orange County; where ill-cultivated fields, and heaps of barren rubbish, are irregularly interspersed amongst copse-woods and forests.*

The rocks, generally, bear 30°–40° E. of N.—W. of S.,† dip 70°–85° N.W., and consist, for the most part, of clay-slates, flecked here and there with chlorite and talc. Their prevailing hues are buff, bluish-grey, and brown; but yellowish and reddish shades are not uncommon. Within short distances of the beds which yield gold they are frequently of thick lamellar structure; but elsewhere they are often fissile.

At distant parts of the series, but on the same meridian, several parallel bands, strictly conform to the schistose structure of the adjoining rocks, but materially differ from them in composition. In width, they are seldom less than four, or more than thirty, feet. Their ingredients are, for the most part, quartz and slate;—which are often thoroughly transfused; though masses indifferently of either, are sometimes imbedded in a matrix of the other; and at intervals they form thin, separate layers; occasionally, however, angular and

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* At and near this place the bloodiest battles of the war of secession were fought.

† In 1840 the magnetic variation was about 1° E.
SABINE, *Phil. Trans.*, 1849; Pl. XIV.

vein-shaped bodies of translucent and milk-white quartz are enveloped in siliceous matter, tinged more or less with red or brown earthy iron ore.* Small quantities of auriferous iron-pyrites, oxydulated iron, and yellow copper-ore, beside grains and particles of gold in still smaller proportions, are irregularly scattered through the beds of ferruginous quartz; and, yet more sparingly, through the slates † which adjoin them,

One of these deposits has been wrought to a depth of fifteen fathoms.

Ore culled, in 1852, from the produce of earlier operations, yielded the undermentioned proportions of gold:—

Nature of ore.	Proportion of (unrefined) gold. ‡
Quartz, mixed with earthy brown iron-ore	.. 0·00023214 §
Slate, mixed with quartz, earthy red iron-ore, and iron pyrites ..	.. 0·00004056 §

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* *Ante*, pp. 181—2, 301—2.

† *Ibid.* pp. 178, 186, 299, 300,—1,—2,—4.

‡ Johnson and Matthey, *Prospectus of the Chancellorsville Mines* (1854), p. 3.

§ From a similar formation at *Walton*, in Louisa County, some miles south-west of *Grasty*, the following proportions of gold were obtained:—

Nature of ore.	Proportion of unrefined gold.
(1.) Quartz, slate, brown iron-ore, and iron-pyrites; from which "all the visible gold had been carefully picked."..	.... 0·00011905
(2.) Quartz, slate, and brown iron-ore; an average of the general produce	.... 0·00028571
(3.) "Quartz, taken at random from the heap of ore"	0·00071429
(4.) Quartz, "pieces selected on account of their showing "gold to the naked eye"	.... 0·00467857

Silliman, *American Journal of Science*, xxxii. pp. 109—115.

The different proportions of silver associated with the gold in various matrices are shown in the following columns.

Nature of matrix.	Proportions of Gold.*	Proportions of Silver.*	Totals.
Quartz, mixed with earthy brown iron-ore	0·776	0·224	1·
Slate, mixed with quartz, earthy red iron-ore, and iron-pyrites..	0·767	0·233	1·

At *Grasty*, therefore,—as well as at *Morro Velho*†

* Mitchell, *Prospectus of the Chancellorsville Mines*, p. 3.

"Silver is occasionally found in connexion with the gold."
Rogers, *Geological Reconnoissance of Virginia* (1836), p. 68.

† At *Morro Velho*, certain poorer and lighter kinds of selected ore, which the *stamps-water* (*Table VII.* Note *i*) washes off the *Canöas* and deposits on the (*Praia*) margin of a neighbouring river (*Ante*, p. 355), are there collected and again *stamped*, with slightly auriferous ("*killas*") slate and other ingredients of inferior quality. But as the gold they afford is less (fine) pure than that contained in the richer ore, the two are reduced separately.

The first two of the following analyses were made by Messrs. Johnson and Matthey after the last had been already printed (*Ante*, p. 334, Note ††).

	Metal obtained from the richer ores. (1.)	Metal obtained from inferior ores and (*killas*) slate. (2.)	(3.)
Gold	0·8083	0·7910	0·7499
Silver	0·1850	0·1865	0·1793
Lead	0·0010	0·0090	0·0180
Bismuth	0·0020	0·0020	0·0135
Copper	0·0008	0·0015	0·0045
Antimony	0·0007	0·0055	0·0030
Arsenic	0·0022	0·0030	0·0105
Iron	—	0·0010	0·0195
Mercury (traces) and loss..	—	0·0005	0·0018
	1·	1·	1·

John Hockin, Esq., Managing Director of the Saint John d'el Rey Company, MSS.

and *Gongo Soco**—the more largely the matrix is impregnated the greater is the *(fineness)* purity of the *(crude)* gold.

(*b.*) At *Woodville*, some three miles north-east of *Grasty*, the yellowish buff-coloured, thin-lamellar, talc-slate, which ranges 15°—20° E. of N.—W. of S., and dips 65°—75° W.; is conformably interlaid by two auriferous beds, about six fathoms apart. To a depth of thirteen fathoms, one averages about fifteen, the other perhaps seventeen, feet; at intervals, however, portions of both are merely a few inches wide. Like the corresponding bands at *Grasty*, they consist in great measure of quartz † and slate; often largely interspersed and deeply tinged with earthy brown iron-ore, but sometimes thinly sprinkled with iron-pyrites.

"It has been proved, by repeated experiments during the year, that—owing, "probably, to a larger amount of silver,—the precious metal contained in the "*killas* is, in quality, four *carats* inferior to that obtained from the (pyrites) ore." DIETZSCH, *Reports of the Saint John d'el Rey Company*, XXXV. p. 52.

* *Gongo Soco, Table IX.*, columns 2—6, 46—7.

Depths, fms.	Workpeople.			Gold.	
	Europeans	Free Brazilians and Slaves.	Totals.	lbs. (*Troy*) extracted.	Purity (*Toca*) fineness of
41·	198	578	776	2,988·456	21 carats 0·7 grains.
70·	—	—	685	514·502	20 „ —

† "The material of the [gold] veins is a variegated quartz, sometimes trans-"lucent, at others opaque. It is generally of cellular structure, fractures with-"out much difficulty, and in many instances contains a considerable quantity of "water. Its surface, recently exposed, displays a variety of tints of brown, "purple, and yellow, of such peculiar aspect as to resemble a thin lacquer spread "unequally over the rock. The cavities are often filled with a bright yellow "ochre, or hydrated peroxide of iron, which generally contains gold in a state "of minute division. Sulphuret of iron (pyrites) is another accompanying "mineral, which in many mines occurs in considerable quantities."

ROGERS, *Geological Reconnoissance of Virginia*, p. 67.

Featherstonhaugh, *Excursion through the Slave States*, II. p. 355. *Ante*, p. 322.

Although no part is, perhaps, absolutely barren,* most of the gold is disseminated either in the earthy brown iron-ore, or—within short distances of certain short joints and drusy cavities—in the quartz.

(*c.*) At *Whitehall*, in the county of Spotsylvania, gold is likewise scantily strown through a similar matrix of quartz, slate, and earthy brown iron-ore; and rich granules are—like the native silver of *Trebisken-green*,†—here and there encased in small masses of galena.‡ Trifling quantities of black tellurium also occur in the quartz,§ and sometimes encrust the gold.

(*d.*) At the *Buckingham (Hesse's* and *Eldridge's)* mines, near Maysville in the county of Buckingham, a rather fissile and somewhat contorted clay-slate,‖ of homogeneous texture and leaden hue,—the lowest rock observed in that neighbourhood,—is succeeded by a narrow band of whitish quartzose mica-slate,¶ fre-

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* "Besides the auriferous veins of the region in which gold occurs, there exist "many other veins of quartz agreeing with those which have been found produc- "tive in nearly all particulars, save that of containing a valuable proportion of "the precious metal. It is probable that none of these veins are entirely desti- "tute of gold, and in many instances no doubt the prosecution of the vein would "lead to the discovery at other points of it, of an ore sufficiently rich to reward "the labour of extraction. Indeed, it must be looked upon as probable, that "the auriferous character, more or less, pervades the quartz-veins generally. " * * * The striking similarity in the character of them all, and the obvious "*contemporaneousness of their origin*, would seem to give great plausibility to "this opinion."—Rogers, *Geological Reconnoissance of Virginia*, p. 70.

† *Ante*, p. 120, Note.

‡ Rogers, *Geological Reconnoissance of Virginia*, p. 68.

§ Henwood, *Cornwall Geol. Trans.*, vii. p. 229. (Whitney's) *Metallic Wealth of the United States*, p. 128.

‖ Rogers, *Geological Reconnoissance of Virginia*, p. 71. *Reports on the Geological Survey of Virginia*, 1839, p. 47; 1840, p. 49. Henwood, *Mining Journal*, 29th January, 1853; (Whitney's) *Metallic Wealth of the United States*, p. 128.

¶ "Rogers, *Geological Reconnoissance of Virginia*, p. 72; *Reports on the Geological Survey of Virginia*, 1839, p. 46; 1840, p. 48. Henwood, *Metallic Wealth of the United States*, p. 128.

quently interspersed with talc; the auriferous deposit,* which succeeds, is overlaid by thin lamellar greenish-white chloritic talc-slate,† now and then flecked with mica.

The series, generally, ranges 20°—30° E. of N.—W. of S. and dips 40°—50° S.E.‡

The metalliferous bed §—conforming to the dissimilar flexures of the rocks on opposite sides,—varies in width, from three to twenty feet on the north-east, but from four to five only towards the south-west. The north-eastern portions consist, near the surface, of granular, massive, and cellular quartz; sometimes imbedded in, but frequently mingled with, earthy brown iron-ore. Traces of galena occur at intervals; and small drusy cavities often afford crystals of the phosphate of lead, and of selenite. The quartzose parts contain bodies of friable iron-pyrites; of which the most deeply seated are the largest and most numerous.

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* Henwood, *Mining Journal*, 29th January, 1833; (Whitney's) *Metallic Wealth of the United States*, p. 128. Ansted, *Scenery, Science, and Art*, p. 288.

† Rogers, *Geological Reconnoissance of Virginia*, p. 72; *Reports of the Geological Survey of Virginia*, 1840, p. 48. Henwood, *Metallic Wealth of the United States*, p. 128. Ansted, *Scenery, Science, and Art*, p. 288.

‡ Partz, *American Mining Magazine*, II. p. 379. Henwood, *Metallic Wealth of the United States*, p. 128. Ansted, *Scenery, Science and Art*, p. 288.

§ At the "Buckingham Mines and those of Mr. Eldridge, the ore * * * is "an auriferous pyrites, occurring in a whitish or white schist. The vein is "worked at a depth of 90 feet, or thereabouts, but has been proved to 160, and "remains uniform. It yields about (0·00000919 its weight) 6 dwts. of gold to "the ton, and some silver. Of this there seems an indefinite quantity; and "from the Buckingham mine there were obtained about 1500 ounces of "gold in the course of last year. The expense of getting and reducing is "estimated at 15 shillings per ton, but there is much loss. About 20 tons of ore "per day are crushed and amalgamated on an average, the daily yield lately "being (0·00000995 its weight) 130 dwts. * * * About 80 feet down from the

These—like the productive deposits at *Morro Velho** *Cronebane*,† and *Connorree*‡—enclose isolated masses of copper-pyrites; § invested occasionally with copper-glance, but more generally with earthy black copper-ore. The south-western portions include many unconnected, angular blocks of slate; ‖ of all which the compositions resemble, and the planes of structure conform to, the compositions and structures of the rocks in their respective neighbourhoods. Except in this particular, and that massive quartz is more abundant, the south-western parts differ but little from the north-eastern.

" surface threads of copper ore were found, consisting of copper pyrites mingled " with the iron pyrites which forms the staple. These have gradually increased, " but at present there seems little chance of any very important result for copper. " * * * Little oxide of iron appears here at any considerable depth below the " surface."—ANSTED, *Scenery, Science, and Art*, p. 288.

* *Ante*, p. 195; *Table VI.* columns 8, 11, 14, 17.

† Weaver, *Geol. Trans.*, v. (o.s.) p. 215. Henwood, *Proceedings of the Royal Geol. Soc. of Cornwall*, 9th Oct. 1840.

‡ Henwood, *Proceedings of the Royal Geol. Soc. of Cornwall*, 9th Oct. 1840. Smyth, *Records of the School of Mines*, I. p. 283.

§ This ore afforded—

0·230000 its weight of copper;—
0·001142 ,, silver;—
0·000060 ,, gold.

JOHNSON & MATTHEY, *Prospectus of the London & Virginia Mining Company*, p. 2.

At *San Pedro* near Copiapò a thin natural gilding covers the faces of certain short joints in a rich mass of grey copper; and grains of gold are imbedded in the same ore.—SAMPSON WATERS, ESQ. of Copiapò, MSS.

‖ " In many places, * * * the *lodes*, when large, consist almost wholly of a " very white crystalline quartz, abounding in drusy cavities *(vughs)* lined with " crystals of the same, and enclose innumerable disjoined pieces of slate. These " masses of slate are in general very sharply defined, present but few traces of " transition into the quartz, and are commonly very uniform in their positions; " frequently, however they have a sort of flinty character which obscures any " traces of cleavage. The cavities lined with crystals, and the included spots " of slate, are most unequivocal signs of poverty, wherever they may occur."
HENWOOD, *Cornwall Geol. Trans.* v. p. 229.

In 1852 the mines were about twenty-six fathoms deep; but, from fourteen fathoms downward, the—almost exclusively pyritic—formation remained unwrought. The earthy brown iron-ore and the quartz are slightly auriferous when separate; but when united in certain manners and proportions, — more easily recognized than described,—they frequently enclose small *nuggets*, thin plates, and crystalline grains, united by threads of gold; which constitute from 0·0000056 to 0·0000070 of the ore extracted.

(*e.*) At the *(Booker) Garnett* and *Moseley* mines, north-west of Willis's* mountain in Buckingham, the auriferous series bears 30°–45° E. of N.—W. of S., and dips 25°—80° N.W.† The rocks contain mica, talc, and chlorite, in large, but ever-varying, proportions; as one or other prevails, therefore, portions—as well of

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* "A gneiss of a very peculiar description occurs in Willis's mountain, Buck-"ingham, associated with several interesting minerals. The rock is generally "of a rich pink or purple, owing to a large proportion of the oxide of iron "disseminated through it, causing it moreover to be very ponderous. The mica "and augite, which appear to be large components of the mass, give it a very "brilliant aspect. * * * It is sometimes studded with minute cells, containing "hematitic oxide of iron. Nearly the whole of the principal peak of the moun-"tain is made up of this beautiful rock, which, rising in the form of a wedge to "the height of several hundred feet, presents a narrow wall of nearly vertical "strata along the summit. The dip is west."

Rogers, *Geological Reconnoissance of Virginia*, p. 63.

† "Between the Buckingham and Eldridge mines, and the Garnett and "Moseley, abundance of iron and quartz appear at the surface. The latter mines "are opened on rocks about 1½ mile east of the former, and probably belong to "different bands of quartz. The strike is somewhat different and the dip much "more considerable, amounting to as much as one in four for the first 100 feet "from the place where the rock begins to hold together. The strike here is "north and south, ranging a little to east of magnetic north, and in some places "changing to north-east and south-west."

Ansted, *Scenery, Science, & Art*, pp. 288—9.

the same, as of different laminæ—but a few inches apart, are of either micaceous, talcose, or chloritic slate.* Near *Garnett's* old engine-shaft, a south-western part of the works long since abandoned, blocks of gneiss are mixed with heaps of other rubbish.

The *principal, Western, Black, Seay, Big-hill,* and other, smaller, auriferous beds, in, and immediately north-west of, the *Garnett* and *Moseley* mines, maintain a tolerable parallelism; except where they are affected by unequal flexures of the adjoining rocks; to the schistose structure of which they strictly conform.

Portions of the	*Principal*	bed are	as much as	16	feet wide	;
"	*Western*	"	"	5	"	;
"	*Black*	"	"	4	"	;
"	*Seay*	"	"	4	"	;
"	*Big-hill*	"	"	18	"	;

but their average widths are much less; and, within short distances, some of them divide, dwindle, and die away; occasionally, however, they reappear and again enlarge.

The slates beneath the *principal* bed underlie 40°—60° N.W., but those above it preserve the same inclination to a depth of ten fathoms only, and thence downward dip 20°—30°. As the *(hanging-wall)* north-

* At the Garnett and Moseley mines "the surface shews a belt more ferruginous "than the rest of the country around, ranging north-north-east and south-south-"west, and dipping west. * * * It is, however, subdivided, including distinct "bands of mixed quartzy threads and rotten red and yellow or greenish schists. "On these repose bands of talcose or chloritic schist, which pass into an im-"perfect steatite. * * * All these are on the east or lower side of the series. "In the middle, between the two well-marked auriferous bands which next suc-"ceed, is a certain thickness of hornblendic greenstone, hard, and tolerably "compact."—Ansted, *Scenery, Science and Art*, pp. 289—90.

western side recedes from the *(foot-wall)* south-eastern, and the auriferous bed between them becomes broader, it encloses, lengthwise, a wedge-shaped *(horse)* mass of slate; which widens downward,—partakes, in some measure, the mineral character of the surrounding vein-stone,—and in structure coincides with the neighbouring rocks.*

In 1852 the only works more than seven fathoms deep, were on the *principal* bed, where they were nearly sixteen fathoms.

Quartz and slate—though differently apportioned and disposed in divers parts of the auriferous deposits, —are always chief ingredients; small quantities of felspar are scattered throughout; but earthy brown iron-ore—albeit in abundance—occurs near the surface only. Deeper portions of the *principal* bed, however, afford also calcareous spar, iron-pyrites, and crystals of common garnet.† Short, thin veins of felspar, quartz, or calcareous-spar,—sometimes enclosing other substances,—intersect all these metalliferous beds at intervals; irrespective of their slightly foliated structure, which is generally parallel to the cleavage of the adjoining strata.

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* *Ante*, pp. 191—4, 251.

† "The enclosing rock, which within 20 feet of the surface is hardly to be "distinguished from the vein, gradually changes below this point, and within a "depth of 10 or 15 feet becomes a hard compact talcose schist, often containing "fine-garnets, and not unfrequently iron pyrites. In this schist, at a small depth, "are a multitude of quartz threads, and farther down these threads come together, forming a distinct quartz band, often enclosing portions of the schist. "The gold disseminated indifferently near the surface, amongst the quartz, "rotten schists, and enclosing walls, gradually collects together into threads, "usually ranging with the schistose portions within the quartz band."

Ansted, *Scenery, Science, and Art*, p. 290.

The shallower parts of all contain particles and grains of gold; but at greater depths in the *principal* bed, flakes, granules, *nuggets,* and threads here and there intertwine the quartz with groups of golden filigree. Tellurium often accompanies the gold; but it is never abundant.*

The richer portions maintained—without appreciable *(shoot)* endlong dip, or material change of hardness,—the same horizontal extent for many fathoms of vertical range; and, for two or three years, they were *(stoped under-hand* †) wrought by much the same numbers of (slaves) ‡) workmen, as fast as the mines were deepened. The weights of gold obtained in equal times, afford, therefore, some clew to the comparative richness of the vein-stone at different depths.

Years.	*Garnett Mine.* Gold; Annual produce of; lbs. *Troy.*	*Garnett Mine.* Gold; Annual ratio of.	*Moseley Mine.* Gold; Annual produce of; lbs. *Troy.*	*Moseley Mine.* Gold; Annual ratio of.
1850...............	—	—	97·92	1
1851...............	36·75	1·	71·74	0·732
1852 (8 months).	20·17	0·823	31·19	0·478

* *Ante,* p. 336, Note.

† Carne, *Cornwall Geol. Trans.,* III. p. 70. *Ante,* pp. 283—4.

‡ From 1850 to 1852 slaves were hired at (100 *dollars*) £20 : 16 : 8 a year each.
The rations allowed them were—

2⅓ lbs. of Indian-corn meal, which cost rather less than (one penny three farthings)	0 : 0 : 1¾ per day	,,
½ lb. ,, Bacon ,, (twopence)................	0 : 0 : 2 ,,	,,
The food of each slave cost therefore (less than four pence)	0 : 0 : 4 ,,	,,

W. M. Moseley, Esq., MSS.

From 1840 to 1848 the hire of slaves in Brazil averaged (one hundred *milreis*) £11 : 5 : 0 a year each. *(Table IX.* Note *c.)*
,, — ,, their rations consisted, however, of fresh beef, bacon, beans, Indian-corn meal, and vegetables; beside coffee, sugar, and rum *(Ante,* p. 292, Note).

In Brazil, therefore, the slave-owner derived less profit, but the slaves were better fed, than in Virginia.

These results show the proportion of gold to have been larger in the shallower and narrower, than in the deeper, wider, and flatter * parts of the *principal* bed.

Selected samples contained (3 *oz.* 16 *dwts.*†) 0·035659 ; but ores from a depth of fifteen fathoms in the

	grains per ton		
Garnett Mine yielded, on an average,	(242·36)	0·000015	their weight of gold.
Moseley ,, ,,	(194·87)	0·000012	,, .

Choice specimens of ore from both mines afforded gold 21 *carats* 1·375 *grain* fine.†

	dollars.			
The 108·49 lbs. *(Troy)* of gold obtained in 1851 realized	(24,015·45)	£5003	2	6
,, cost of extraction ‡ .... amounted to	(12,562·00)	2617	1	8
,, year's operations, therefore, gave .. a profit of	11,453-45	£2,286	0	10

The beds of many streams have afforded large

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* Thomas, *Report on a Survey of the Mining District from Chacewater to Camborne*, p. 20. Henwood, *Cornwall Geol. Trans.*, v. p. 231. *Ante*, pp. 82–3.

† Johnson & Matthey, *Prospectus of the Garnett & Moseley Gold Mining Company*, p. 2.

‡ "Expense of working the *Garnett* and *Moseley* mines during the year 1851."

Salaries of two Superintendents....................	700	dollars.
Wages of two Miners	600	,,
,, two Engineers and their two Assistants	700	,,
Food of Miners and Engineers	360	,,
Hire of sixty Slaves ...... at 90 dollars a year each..	5,400	,,
10,920 lbs. of Bacon ...... ,, 8 cents per lb.	880	,,
262 barrels of Indian-corn. ,, 3 dollars per barrel....	792	,,
Clothing for Slaves	600	,,
Keep of Cattle	430	,,
Iron, Steel, Rope, Powder, Safety-fuse, &c.	2,100	,,
	12,562	dollars.

W. M. Moseley, Esq., MSS.

quantities of detrital-gold;* but, with few exceptions,† the masses have been small.

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* "In the county of Louisa great success attended the operations of some "persons who had unexpectedly come upon an extraordinary rich bed of auriferous "gravel, from which in six days they extracted native gold, in grains, of the value "of ten thousand dollars. * * * Soon after this discovery, the vein from whence "it was derived was also found, consisting of a pale porous quartz, thickly studded "with knobs and laminæ of native gold, and upon comparing specimens of it "with" that obtained from the gravel "I found that many of the *pepitas*, or "knobs of gold, corresponded in form, although the alluvial gold was rounded "and worn by the action of the water."

Featherstonhaugh, *Excursion through the Slave States*, II. p. 353.

"Nothing is more common in these deposits than to find masses of quartz "with small lumps of native gold imbedded in them, resembling in every par- "ticular, others which are taken from veins now in place, the heaviest masses "being always found nearest to the auriferous strata, and the particles of gold- "dust at the greatest distance from them."—*Ibid*, p. 351.

"Washings were formerly carried on successfully in a small gully running "through the (Waller) estate; and on searching for the veins whence the "auriferous sands had been removed, they were found distinctly marked close "to the surface."—Ansted, *Scenery, Science, and Art*, p. 284.

"In the alluvial deposits gold is sometimes very much water-worn and in "comminuted particles and sometimes in nuggets of a considerable size, rough "and angular with quartz still adhering to them as if they had not been carried "far from the vein whence they were detached. * * *

"Silver is always associated with the gold [of Canada] to the extent of from "10 to 15 per cent."

Dawson, *Report on the Canadian Gold Fields*, p. 80. (1865. Printed by order of the Legislative Assembly.)

† A *nugget* of nearly nine pounds, beside many masses of a few ounces each, "were mixed with grains of gold in the bed of a rivulet immediately south of "the *Garnett* and *Moseley* mines.

Major Miller, Superintendent of the *Moseley* mine, MSS.

"A subterranean Indian village was discovered in Nacooche valley, Georgia, "by gold miners, in excavating a canal for the purpose of washing gold. The "depth to which it is covered, varies from seven to nine feet; some of the houses "are imbedded in a stratum of rich auriferous gravel. They are 34 in number, "built of logs from six to ten inches in diameter, and from ten to twelve feet in "length. The walls are from three to six feet in height, forming a continuous "line or street of 300 feet. The logs are hewed and notched as at the present "day. The land beneath which they were found was covered, on its first settle- "ment by the whites, with a heavy growth of timber."

Dickson, *Trans. Geol. Society of Pennsylvania*, I. p. 25.

On the Native Copper of Lake Superior.

The rich metalliferous series immediately south of Lake Superior, overlies three large ranges, and several smaller tracts, of granite.* The first reaches the shore near Presqu' isle and Huron river;–the second extends from Chocolate river beyond the Machi-gamig;—the

* "Granite forms, for the most part, the rim of the Lake Superior basin. * * * It appears in low, undulating hills, nowhere attaining a greater elevation than (1,873 feet above the lake) 2,500 feet above the ocean. On the northern shore, it is more widely distributed than on the southern; but its geographical boundaries have been imperfectly determined. * * *

"Granite forms the coast between Presqu' isle and Granite Point. Proceeding westwardly, it expands rapidly until it attains a width of twenty-five miles. * * * The extreme length of this granite axis is sixty miles, and its culminating points rise 1,200 feet above the lake.

"Another granite boss rises to the south of that above described, and ranges in a nearly parallel direction for about thirty-six miles. The interval between them is from twelve to fifteen miles in width. * * *

"Farther west, another granite belt starts from the head waters of the Ontonagon river, and thence extends to the western limits of the district. * * * It is probable that this belt is a continuation of that first described, but we have not been able to trace the continuity. * * *

"There are, also, numerous insulated patches of granite scattered through the crystalline schists. * * *

"The Huron, Granite, and Middle islands, as well as several islets off Presqu' isle, belong to the same formation.

"The granite, for the most part, forms numerous parallel ridges, bearing east and west.

"Several systems of joints cut the rock into tabular plates, which will materially aid the quarry-man in his labours."

Felspar and quartz are always the principal—and sometimes they are the only —components; but, in general, either mica, hornblende, or chlorite is also present.

"The granite of Middle island is intersected by powerful dykes of greenstone, some of which are ninety feet in width, and we counted no less than six within the distance of forty rods. They cut the greenstone in remarkably straight lines, leaving clean, smooth edges. * * * In the smaller dykes, the greenstone is very compact and fine grained; but in the larger, whilst it exhibits this texture near the edges, towards the centre it becomes highly crystalline. * * * There

third comprises the sources of the Ontonagon and the Montreal.

The granite is generally succeeded by gneiss,* but

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are two systems of dykes; one set bears nearly east and west, while the other bears north-east and south-west; these, in their turn are intersected by veins of quartz.

In section I., along the east boundary of township 49, range 27, "a ridge of granite * * * bearing N. 20° E. * * * is traversed by powerful dykes of greenstone in a direction parallel to its prolongation. There are also seen numerous granite veins, seldom exceeding eight inches in width, ramifying through the granite, and occasionally through the greenstone. Mica is more abundantly disseminated through these veins than in the adjoining walls. * * *

"At the junction of the granite with the azoic slates on the southern side, the relation of the former to the latter is clearly seen. The slaty rocks are traversed by * * * veins of granite, which gradually increase in number and dimensions as we approach the granitic nucleus. On an almost vertical wall of rock, about forty feet in height, near the south-east corner of section 25 (township 47, range 27,) the granite is seen penetrating the hornblende-slate like an immense wedge, and shooting out in ramifying branches. * * *

"The granite which forms the axis between the river systems of the two lakes [Superior and Michigan] * * * has disturbed the upper beds of slates, while the lower beds of the Potsdam sandstone rest undisturbed around it. * * *

"Of the whole district the granitic region possesses the least economical value. There appear to be no metallic veins worthy of exploration, and from the broken and rugged character of the surface, it is ill adapted to agricultural purposes." * * *

Foster & Whitney, *Report on the Geology of the Lake Superior Land District;* Part ii. (1851) pp. 38—48 (Abridged).

Geological Map of the Lake Superior Land District, in the State of Michigan; prepared pursuant to an Act of Congress; by J. W. Foster and J. D. Whitney, United States Geologists.

* Between township 49 range 32 and Keweenaw bay the rocks succeed in the following order:—

"1. Granite. * * *

"2. Gneiss, with a large amount of mica.

"3. Compact hornblende, with silex in places predominating.

"4. Chloritic, argillaceous, and silicious slates. * * *

"On the southern flank the following was the order of succession observed.

"1. Granite. * * *

"2. Quartz and feldspar passing into granular quartz.

"3. Compact hornblende, traversed by numerous joints.

"4. Magnetic and specular oxide of iron, with thin laminæ of white, granular quartz. * * *

"On approaching section 31, township 46, range 29 * * * closely grained

sometimes by hornblendic-rocks; which occasionally alternate with, but are more frequently followed by, quartzose, micaceous, talcose, or chloritic slates; and these pass gradually into clay-slate, which assumes here and there an arenaceous character.* In many of the upper strata lime † is an abundant ingredient.

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and firmly cemented hornblende rocks appear * * * in dark green masses. * * * On the adjoining section south the granite appears in low, rounded outcrops * * * flanked on the south by hornblende, presenting the same lithological character as that on the north. * * *

"Near the south boundary of township 42, range 31, the granite pierces through the incumbent strata, * * * . On either side corresponding alternations of hornblende and mica slate are observed, * * * which are found to graduate into chlorite and argillaceous slates. * * * At portage No. 2 the chlorite slate contains numerous vesicles filled with calc spar. * * * Associated with them are seams of quartz ranging and dipping with the enclosing rocks. They often contain scapolite, and the sulphuret of iron and copper. The metallic contents, however, of these seams were regarded as worthless. * * *

"The granite rises in low ridges from amidst the talcose, hornblende, and chlorite slates, in townships 41, 42, 43, and 44, through the whole district westward to 45. * * *

"Granite is the predominating rock below the southern boundary of township 47, and is associated with a hornblende-rock, which sometimes assumes a slaty structure."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, Part ii. (1851) pp. 20—57 (Abridged).

* "In higher parts of the series, the argillaceous slates become interstratified with argillaceous sandstones."—*Ibid*, p. 12.

† "Calcareous bands occasionally occur of sufficient purity to be called limestone. * * *

"In the north-east quarter of section 2, township 47, range 25, a band of slaty limestone, somewhat silicious, is seen beneath the quartz. * * * In the northern part of section 3, the quartz is interstratified with another band of limestone. * * *

"In section 31, township 48, range 25, another band of compact limestone was traced westward, through sections 33 and 36. * * * It is less silicious than that before described, variously coloured, white, ash-grey, and flesh-red, and variously veined with tints of a deeper hue. It calcines readily into lime, and affords beautiful ornamental materials."

Ibid, pp. 12, 15, 16.

Dykes and beds of hornblendic and felspathic rocks occur throughout the system;* but they are numerous in the neighbourhood of certain rich deposits† of iron-

* *Ante*, pp. 385—6, Notes *.

† "The very interesting deposits of iron ores on and near Lake Superior, * * * are in the azoic, and they form literally mountain masses * * * The distance of these deposits from the Lake, at the nearest point is about twelve miles * * * . From this point, the ores of iron are found at intervals in a belt of slates from six to twenty-five miles wide, extending for a distance of one hundred and fifty miles or more westward into the State of Wisconsin."
Whitney, *Metallic Wealth of the United States*, p. 477.

"The principal deposits of specular and magnetic ore [in township 47, range 26,] are arranged in a metalliferous belt, bearing nearly east and west. * * * A small stream which is one of the sources of the Escanàba river is at one point precipitated over a ledge of ore, * * * which consists of a peroxide of iron, mixed with considerable silicious matter, and seems to exhibit indistinct lines of bedding which dip at a high angle, and are intersected, at nearly right angles, by joints which cut the mass into large tabular blocks. * * *

"Along the line between sections 32 and 33, near the junction of the azoic slates with the granite, the relations of the iron to the slaty and quartzose rocks are well displayed. * * * On the north side of a ravine, which extends for a considerable distance east and west, * * * quartzose bands, composed of fine grains of silicious matter, impregnated with peroxide of iron, with occasional wide bands of pure ore, alternate with a hornblende rock, having a schistose structure, and equally charged with ferruginous matter. * * * On the south side of the ravine * * * a succession of trapean and granitic belts, crossed by numerous veins of igneous rock, is presented. Here, however, the rock is no longer charged with iron.

"In township 47, range 27, * * * the ferruginous band, wrought by the Jackson Company, form a ridge about a thousand feet in width, and from a few feet to fifty in height, above the level of the surrounding country, and can be traced almost continuously across the section in an easterly and westerly direction. On the northern side of the belt, the ore is compact, and of great purity; near the centre it exhibits a banded structure, while to the south, it passes again into the compact variety. * * * This deposit is bounded on the south by highly crystalline hornblende and felspar rock, and on the north by slaty chloritic, beds. * * * Numerous veins of quartz cut the great mass of ore, and contain specular oxide in large brilliant plates. * * *

"In sections 10 and 11 west the deposits * * * are, in fact, unrivalled in the abundance and almost absolute purity of the ore. The purest ore occurs in a ridge which extends across the line between these two sections. It rises with precipitous walls to the height of at least fifty feet. * * * The purest portions are a very compact and fine grained specular ore, having an imperfect slaty structure, and traversed by joints, like the slates in the neighbourhood. Through

ore; of which many portions—now largely wrought,*

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this fine-grained base are scattered numerous minute crystals of the magnetic oxide. In other places, the ore is almost entirely made up of an aggregate of crystals of the magnetic oxide, sometimes very minute, and rarely larger than a pin's head. * * * Metallic matter has penetrated the adjoining slaty rocks, and filled them with crystals of magnetic oxide and occasional streaks and bands of fine-grained peroxide of iron. * * *

" Farther south another deposit on a scale of still greater magnitude, though not equal in purity to the ore last described, is known as the Cleveland location. It rises * * * in a ridge one hundred and eighty feet above the stream at its base, one hundred and fifty-two feet above the drift terrace * * * near its northern slope; and forms the culminating point between the two lakes. * * * It is made up of alternate bands of pure fine-grained peroxide of iron and of jaspery ore. The thickness of the bands varies from that of a sheet of paper to one-fourth of an inch. They are not arranged in a constant position, with regard to the general disposition of the mass; but are twisted and contorted in every variety of form and outline; the curvatures are, however, mostly on a very small scale, the radius of curvature in the concentrically folded layers never being as great as one foot in length. * * * The width of this deposit of ore cannot be less, at its base, than one thousand feet, and it may be traced for considerably over a mile in length. * * *

" The largest mass [of ore] observed by us in township 46, ranges 29 and 30, occurs on the left bank of the Machi-gamig. It here rises in a nearly vertical cliff to the height of one hundred and thirteen feet, and is somewhat variable in purity. For the most part, it has a slaty cleavage, and on close inspection, is observed to be composed of alternating bands of micaceous specular iron and quartz, tinged red by the peroxide of iron; but there are occasional belts of granular texture, and apparently of greater purity. These laminæ are nearly vertical, exhibiting few contortions, and range with so much uniformity, that the observer would be inclined to refer both the slates and the iron to a common origin." * * *

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, Part ii. pp. 50—7 (Abridged).

* " The iron ore of Lake Superior * * * can be quarried—for it is not mining—and placed upon the railway carriages, ready for transportation, for less than one dollar (four shillings and two pence) per ton. The average value of the ore is from 60 to 70 per cent. It is safe to say that this portion of Michigan can produce all the iron-ore that is necessary to supply the world with iron for ages, without sensibly diminishing the quantity, or enhancing the value thereof."

The first shipment of ore made in 1855, was		 1,457	tons.
in 1856 there were shipped.		11,597	,,
1857	,,	.. 26,184	,,
1858	,,	.. 30,327	,,
1859	,,	.. 80,000	,,
1860	,,	.. 150,263	,,
1861—3	,,	.. 299,583	,,
1864	,,	.. 235,123	,,
Total in ten years		 834,534	tons.

—resemble, as well in structure as in composition, the *Itabirite* * and *Jacotinga* † of Brazil. Of other ores and metals, however, the traces are few.‡

"The pig-iron produced in 1858 was	2,000	tons.
1859 „	6,000	„
1860 „	6,500	„
Total in three years	14,500	tons.

In 1860 "the average value of the ore on the docks ready for shipment, was about three dollars [twelve shillings and sixpence] per gross ton, and of pig-iron from twenty to twenty-five dollars [four pounds three shillings and four pence to five pounds four shillings and two pence] per ton."

The manufacture of pig-iron "commenced at the Pioneer Works, near the Jackson Mine, in 1858, * * * but the Collinsville, Forestville, Morgan, Northern, and Greenwood furnaces have been since erected. * * *

"The blasts are driven, in some cases by water—which is abundant and can be used during the severest winters, but in some cases by steam, the gas from the furnace been taken as fuel. The usual pressure is 2 lbs. per square inch, and the temperature 620° F.

"Charcoal [the only combustible used in the furnace) is made almost entirely in kilns 25 to 30 feet in diameter, and 25 to 30 feet high, shaped like a straw bee-hive, and capable of burning 30 or 40 *cords* in 17 days; 20 to 25 of these kilns are required for each furnace, and they are scattered through the forest in the neighbourhood of the heavy timber. Maple and birch, with some hemlock, are the woods charred; 2½ *cords* are found to produce 100 bushels. Charcoal is now being delivered at 11 cents [five pence halfpenny] per bushel, by contract. It requires 125 bushels of charcoal to reduce one ton of iron, and the furnaces produce from 10 to 18 tons in 24 hours. The flux used is a limestone found near the railroad, and which does not cost over 35 cents [one shilling and five pence-halfpenny] per ton of iron. * * * The cost of making iron is now (1865) about thirty dollars [six pounds and five shillings] per ton. * * *

"Land, from which may be cut an average of 50 *cords* (6,400 cubic feet) of wood per acre, may be bought at from two dollars and a half to four dollars [ten shillings and five pence to sixteen shillings and eight pence] per acre in hundreds of places along the shores of the lakes. Two competing lines of railway already lead from the mines to the lakes."

Legislature of Michigan, 1861; *Report of the Joint Committee of the Senate and House of Representatives;* No. xix. p. 6. Lamborn, *Mining Journal* (5th Aug., 1865) xxxv. p. 509 (Abridged).

* *Ante*, pp. 211, 214, 219, 221, 224, 226, 227, 237, 242, 244, 248—9, 251, 298.

† *Ibid*, pp. 212, 214, 219, 223—4, 227, 229, 230—6, 242, 245, 251—81; Fig. 20.

‡ "The results of our enquiries have led us to believe, that, aside from iron, the metallic products of the azoic series will prove of little value. We have

Veins of granite penetrate the lower hornblendic rocks, but do not extend to the calcareo-siliceous slates.

The nearly horizontal beds of sandstone,*—which occur in the plains and on the smaller hills, but never

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not seen a regular well-defined vein of any extent, with well-defined wall-rocks and gangues differing from the enclosing mass. There are fissures and irregular rents which contain metallic products, such as copper and iron pyrites, magnetic oxide of iron [galena, black oxide of manganese], &c.; but they differ from productive lodes in their want of continuity and parallelism."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, Part II. p. 82.

* The "sandstone appears along nearly the entire southern shore of the Lake, from Sant Ste. Marie to Fond du Lac, its continuity being interrupted in only a few points, where the trappean or granitic ranges have been for a short distance denuded of the sedimentary beds which were originally deposited upon them. The general trend of the southern shore is east and west, but at a nearly equal distance from each end of the Lake, the regularity of its outline is broken by a projecting point of land, which extends for sixty or seventy miles in a north-east direction, gradually curving round to the east. This is Point Keweenaw, the locality where, by the present generation, the copper-bearing veins were first opened and worked."—WHITNEY, *Metallic Wealth of the United States*, p. 251.

Geological Map of the Lake Superior Land District; by J. W. Foster & J. D. Whitney. Rivot, *Annales des Mines*, 5me Série, VII. p. 229.

"The sandstones repose nearly horizontally on the basset edges of the slates, or occupy the depressions in the granite." * * * But "while the granite ranges attain in places an elevation of 1,200 feet above the lake, the sandstones, except in the vicinity of the trap, do not reach higher than 350 feet, * * * . Consequently, the granites and slates rise up like islands through this great waste of sandstone."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, II. pp. 110, 114, 122.

"Wherever the sandstone comes in contact with the granite, or prior-formed schists, it is observed to have a slight inclination *away* from the older rocks, rarely exceeding 8° or 10°."—*Ibid*, p. 136.

"At a distance from all igneous action where the sandstone has been regularly deposited and not subjected to any disturbing influences, it appears to be made up almost entirely of angular fragments of nearly pure quartz, which are hardly held together by any visible cement. The grains are generally of the size of a pin's head, and often present crystalline facets. * * * In general, however, it is somewhat coloured by a trace of iron. In the vicinity of the trappean rocks, it becomes highly charged with iron and calcareous matter."

Ibid, pp. 190—1.

Near Portage lake "some of the strata consist of silex, with thin plates of mica interspersed, whilst others contain portions of alumine, coloured red by oxide of

reach the higher ranges,—unconformably overlie the lower, and abut on the upper, slates; though here and there they touch the granite.

Quartz—sometimes the only,—is always a principal component; felspar is generally abundant; and, near the granite, mica is also a common ingredient. Thin layers of conglomerate, containing nodules of quartz and small angular masses of granite, occur at intervals; and calcareous matter is largely diffused through upper members of the series. Many portions are whitish or greyish; but yellow and brown are the prevailing hues.

The position * and organic contents of this deposit

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iron. * * * At Iron river, and at several other points, the sandstone is very fissile and of dark colour, resembling a slaty rock. * * * On Torch river the sandstone * * * consists of yellow or red grains, without any visible cement, enclosing quartzose pebbles and patches of dove-coloured clay."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. pp. 110—15.

"In general this sandstone is composed of fine grains of quartz and felspar, together with rounded particles of primitive and trap rocks; and it is important to remark that no fragment of the Silurian fossiliferous limestones, known to occur to the northward, was ever noticed in its conglomerates. Grains of mica are sometimes abundant, especially near its contact with the granite."

Bayfield, *Quarterly Journal of the Geological Society*, i. p. 453.

Rivot, *Annales des Mines*, 5me Série, vii. p. 229.

* "There seems no reason to think that this formation can be more recent than the old red sandstone; and when it is considered that it appears in the St. Mary's at low levels, forming nearly horizontal strata at the bottom of Lake George, whilst the horizontal fossiliferous limestone of Sugar Island and St. Joseph's rises into higher ridges, so as to make it *highly probable* that the sandstone occupies the inferior position; and that, moreover, a sandstone is known very generally to underlie transition limestone in Canada and the United States: when all this is taken into account it is, perhaps, not unlikely that the sandstone in question may belong to the Silurian rather than the Devonian period."

Bayfield, *Quarterly Journal of the Geological Society of London*, i. p. 453.

"The almost uninterrupted continuity with which this rock can be traced even from its eastern extension through Canada and along the northern shore of Lake Huron to the St. Mary's river, and thence westerly, leaves no doubt as to its true position and identity in age with the Potsdam sandstone of New York.

show that it belongs to the Potsdam sandstone, the lowest fossiliferous * group of North America.

If we were at a loss in thus tracing it continuously, we have still the evidence of the succeeding fossiliferous strata, which show, conclusively, the same relations to this sandstone as they do to its equivalent in New York."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, II. p. 133.

"The evidence afforded by the facts collected by my friend and associate Mr. Murray (published in our Report of Progress for 1847—8), on the Grand Manitoulin, La Cloche, and other islands [in Lake Huron] * * * is clear, satisfactory, and indisputably conclusive. On these islands, the Potsdam sandstone, the Trenton limestone, the Utica slates, and the Loraine shales, successive formations in the lowest fossiliferous group of North America, were each, in one place or other, found * * * resting in unconformable repose, in a nearly horizontal position upon the tilted beds and undulating surface of the quartz rock and its accompanying strata. * * * The conclusive evidence thus given of the Huron [formations] would appear to settle that of the Lake Superior rocks in the position given to them by Dr. Houghton, the late State Geologist of Michigan, as beneath the lowest known American fossiliferous deposits; and in this sequence those of the Huron, if not those of Superior, would appear to be contemporaneous with the Cambrian series of the British Isles."

LOGAN, *Report of the British Association for* 1851, Part II. pp. 60—1.

Bigsby, *Geol. Trans.* I. N.S. p. 193.

* "The *Trilobite* occurs on the Menomonee, while we have the *Lingula* everywhere."—FOSTER & WHITNEY, *Report of the Geology of the Lake Superior Land District*, II. p. 131.

"In 1845 Mr. Forrest Shepherd brought from Tequamenon Bay, two specimens of sandstone containing Lingulæ. The rock was composed of rounded grains of quartz, cemented by calcareous matter. * * * In a small fragment were parts of five separated valves of Lingula, two of them nearly entire. The form of the entire shell is round-obovate, and more elongated in proportion to its breadth than the ordinary specimens of *L. prima* from the same sandstone in New York. Nevertheless I am not prepared to describe it as a distinct species. * * *

"Specimens from the Escanàba river, in the lower part of the calciferous sandstone, resemble, in all their important characters, those from Tequamenon Bay. From the comparison of specimens, I am inclined to unite all these in one species. * * * The calcareous beds on the St. Croix river are crowded with the valves of this species, and another so closely resembling the *L. antiqua*, that I have not found characters to warrant the separation.

"From the number of individuals occurring in the small fragment, from Tequamenon Bay, it is evident that, at that point the rock was highly charged with these forms of organic life. * * *

"In connection with the Lingulæ on the Escanàba river, I collected a number

Keweenaw Point—an irregular obtuse-angled triangle, of which the sides measure respectively about ninety, sixty-five, and fifty miles,*—consists, for the most part, of sandstone, intersected by ranges of trap, which are often, but not always, associated with conglomerates.† The first band extends from the north-eastern headland to Sand bay, a distance of eighteen miles, but it rarely exceeds five furlongs in breadth.‡

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of obscurely pointed triangular bodies, like those described in the Palaeontology of New York as *Thecæ?* * * *

"In the Lake Superior district, the only fossils seen in the Potsdam sandstone, in addition to these just described, are fragments of one or more species of Trilobites, which were found on the Menomonee river. These have the characters of the *Ogygia* or *Brontes;* but those in possession of the survey, are too imperfect to admit of satisfactory determination. A farther examination of the prolongation of this sandstone across the interval between Lake Michigan and the Mississippi and St. Croix rivers, has resulted in satisfying us that the sandstones of the two termini are identical in age, and the Trilobites specifically the same."—Hall (Foster & Whitney's), *Report on the Geology of the Lake Superior Land District*, pp. 203—5.

Bigsby, *Quarterly Journal of the Geological Society of London,* xiv. pp. 338-9, 434—5; xv. pp. 279—80.

* "On nomme *pointe de Keweenaw* la langue de terre qui s'avance vers le milieu de la côte méridionale du lac, en formant une courbe dont la convexité est tournée vers le nord."—Rivot, *Annales des Mines*, 5me Série, vii. p. 206.

† "At the head of Keweenaw Point the trappean rocks are associated with conglomerates."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District,* i. p. 59. *Geological Map of the Lake Superior Land District.*

‡ "The outer belt of trap, occupying the extreme northern portion of Keweenaw Point, is less than a mile in width, and preserves a great degree of uniformity throughout its entire course. * * * From the extremity of Keweenaw Point, it extends westerly for about eighteen miles in a curvilinear direction, and passes into the lake at the eastern point of Sandy bay. Throughout most of this distance it is protected from the action of the surf by a thick belt of conglomerate, but at several points the water has broken through this sea-wall and excavated spacious harbors in the igneous belt. Copper, Agate, Grand Marais, and Eagle Harbors are included in this belt, and owe their origin to a common cause."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 60.

The second, or principal, band, however, traverses the entire length of the promontory, and, there, varies from less than a mile to more than four miles in width; but in neighbouring portions of the Upper Peninsula [of Michigan], as well as Wisconsin, it is still wider.* As the central differ from the outer portions of this formation; these—which also present some diversities of composition—are commonly particularized as the *northern* and *southern* trap-ranges.† Near the extremity of Keweenaw Point both ranges are slightly convex towards the north, but on the whole they bear nearly east and west; further inland, however, the principal range assumes, gradually, a north-easterly and south-westerly strike;‡ but in the Peninsula—once more deflected, though in an opposite direction—it trends 15°—25° north of east and south of west.§

* "A trap range starts from the head of Keweenaw point and runs west twenty miles; then curving to the south-west, crosses Portage lake near its head, and the Ontonagon river twelve miles from its mouth, and is thence prolonged into Wisconsin. Its length is more than one hundred and fifty miles; its width from one to twelve."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 34.

† *Ibid*, pp. 61—4.

‡ "On tracing into the interior the ranges which approach the Lake at the extremity of Keweenaw Point, they are found to extend in a general south-westerly direction along the whole line of the Lake, at a few miles from it."

WHITNEY, *Metallic Wealth of the United States*, p. 252.

"La direction est à peu près E.—O. auprès de Copper-Harbor; elle tourne un peu vers le sud à l'extremité de la pointe de Keweenaw, et vers l'ouest elle devient progressivement N.—E. à S.—O. * * * Auprès du lac Portage, cette direction est N. 55° E. à S. 35° O., et plus loin, vers l'Ontonagon, elle est notablement différente, N. 65° E. à S. 65° W."

RIVOT, *Annales des Mines*, 5me Série, VII. pp. 210, 215.

§ In 1847 the magnetic variation in the Upper Peninsula of Michigan was 5° 35′ E.—WHITTLESEY (FOSTER & WHITNEY'S), *Report on the Geology of the Lake Superior Land District*, II. p. 346.

Throughout this tortuous course, however, it maintains a general parallelism, as well to the beds of sandstone on either side, as to the coast.* On opposite sides of the crystalline rock,† which occurs in the principal range, the beds of trap and conglomerate, together with the sandstones adjoining them, incline oppositely;‡ the northern and north-western portions, towards the north and north-west,§—the southern and south-eastern towards the south and south-east.||

The central crystalline mass, which consists of greenstone, is rarely interlaid by other rocks; on both sides, however, the trap-rocks frequently alternate with broad bands¶ and lenticular bodies of

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* Foster & Whitney, *Geological Map of the Lake Superior Land District.* Rivot, *Annales des Mines*, 5me Série, VII. *Pl. VII.*

† "La chaîne * * * est composée de trapp crystallin, porphyritique et syénitique, disposé par bandes mal définies et qui paraissent parallèles à la direction générale de tous les terrains."

Rivot, *Annales des Mines*, 5me Série, VII. p. 208.

‡ Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 69, *Fig.* 5. Rivot, *Annales des Mines*, 5me Série, VII. *Pl. VIII. Figs.* 2, 4.

§ Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 63, *Fig.* 4.

"Au nord, on rencontre d'abord des bandes de trapp plongeant vers le nord et vers le nord-ouest, ensuite des couches et des bancs de conglomérat, de trapp, de grés, et enfin des grès pareils à ceux du nord, et présentant, comme eux, une inclinaison décroissante quand on les observe en des points plus éloignés de l'axe du soulèvement."—Rivot, *Annales des Mines*, 5me Série, VII. p. 208.

|| "Au sud * * * le grès s'appuie sur le trapp et plonge vers le sud sous un angle assez fort, mais qui devient de plus en plus faible, à mesure que la distance au trapp est plus grande."—*Ibid*, p. 207.

"Le versant méridional plonge vers le sud et vers le sud-est, sous un angle assez variable, mais compris en général entre 35° et 55°; le versant septentrional présente l'inclinaison inverse vers le nord et nord-ouest, sous un angle de 30° à 35°. Plus l'ouest l'inclinaison est plus grande; et dans la région d'Ontonagon elle atteint 55°."—*Ibid*, p. 208.

¶ "In the central portion of the range * * * beds of conglomerate, of very inconsiderable thickness, occur between heavy masses of trappean rock. As we

conglomerate.* In the Keweenaw district thick beds

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recede * * * in either direction, we find that the belts of trap become thinner, the conglomerate predominates, but gradually disappears, and is succeeded by sandstone."—WHITNEY, *Metallic Wealth of the United States*, p. 253.

"North of the Little Montreal river four alternations of trap and conglomerate were observed."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 62.

"Near Copper Falls mine * * * there are not less than five repetitions of [coarse] sandstone and trap within the distance of 2000 feet."—*Ibid*, p. 63.

"Sur les plans de la mine de *Copperfalls* [*Pointe de Keweenaw*] * * * les épaisseurs horizontales des bancs et des couches de trapp, de conglomérat et de grès, sont les suivantes.

Greenstone	500·00 mètres	273·3 fms.
Trapp compacte, grenu, amygdaloïde .	2,100·00 ,,	1,148·3 ,,
Conglomérat	3·50 ,,	1·9 ,,
Amygdaloïde	26·50 ,,	14·5 ,,
Conglomérat et grès	32·60 ,,	17·8 ,,
Trapp en grande parte amygdaloïde..	130·00 ,,	72·1 ,,
Conglomérat et grès	13·00 ,,	7·1 ,,
Amygdaloïde	10·50 ,,	5·7 ,,
Grès	8·25 ,,	4·5 ,,
Amygdaloïde	110·00 ,,	60·1 ,,
Conglomérat et grès	133 00 ,,	72·7 ,,
Amygdaloïde	58·00 ,,	31·7 ,,
Grande zone de conglomérat et grés..	1,660·00 ,,	907·7 ,,
Amygdaloïde	jusqu' au lac."	

RIVOT, *Annales des Mines*, 5me Série, VII. pp. 214—15.

"Auprès du lac Portage * * * au sud, le trapp crystallin et porphyritique passe presque immédiatement sous les conglomérats et sous les grès; au nord, li est recouvert par des bancs successifs de trapp, compacte, grenu, amygdaloïde, épidotique, séparés les uns des autres par des lits trés-minces ou par des couches de conglomérats et de grès."—*Ibid*, p. 215.

"In township 50, range 39, the trap is flanked on the north by a belt of conglomerate, which occupies a width of one-fourth of a mile. Numerous alternating bands of igneous and aqueous rocks are observed."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 73.

"Au sud-ouest du lac Portage et jusque bien au delà de la rivière Ontonagon, la disposition générale des terrains est en grande partie la même qu' à la Pointe de Keweenaw."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 215.

Logan, *Report of the British Association* (1851), Part II. p. 60.

* "Interstratified with this [the northern trap]-belt, throughout its entire range, we observe numerous lenticular masses of conglomerate, which appear to affect the courses of the veins, as well as their productiveness."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 62.

of chlorite * sometimes divide the sandstones and conglomerates from the trap for several miles; but near Ontonagon layers of epidote† prevail.

The anticlinal axis, of crystalline greenstone, is flanked, on both sides, by trap-rocks which—whether of granular, compact, or crystalline structure,—often interlie, but sometimes enclose, bodies of amygdaloid and conglomerate.‡

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* From the cliffs of hornblende and labradorite north of the Montreal river "a band of conglomerate from twenty to fifty feet in thickness can be traced almost uninterruptedly for a distance of twenty-five miles. At the Cliff and North American mines a bed of chlorite rock occupies a corresponding position."
Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 62 (Abridged).

A belt of chlorite, which expands to about 150 feet in thickness, between the trap and sandstone near Lac la Belle * * * "is found to continue almost uninterruptedly to Portage lake; always preserving the same relation to the rocks above and below it. Such occurrences are not uncommon in this district."
Ibid, pp. 65—6 (Abridged).

"A red and green chlorite rock, fissile, but not stratified, enveloping masses of amygdaloid, is seen * * * on an affluent of the Torch river."—*Ibid*, p. 67.

† "In township 50, range 50, west of the Ontonagon * * * a vein-like mass of epidote can be traced from the bottom to the top of a hill, and for a considerable distance along the course of the formation; * * * It has no perceptible walls, and on either side it may be seen graduating into the trap."—*Ibid*, p. 74.

"On section 35, is a high cliff made up of irregular alternating bands of amygdaloidal trap and amygdaloidal epidote."—*Ibid*, p. 75.

‡ "The usual mineral components of the trap are labradorite and augite, with a smaller proportion of various other minerals, amongst which magnetic oxide of iron, chlorite, and epidote are the most abundant, with smaller quantities of the zeolitic minerals and calc-spar, as accidental ingredients. The feldspathic and augitic portions are usually finely granular, and form a compact homogeneous paste, in which the others are embedded; and the recognized differences in the characters of the different trappean beds do not seem to depend so much on chemical composition as on mechanical structure; as they seem in most cases to contain the same or very similar mineralogical components, in very different conditions of mechanical aggregation."
Whitney, *Metallic Wealth of the United States*, p. 253.

"Le trapp forme des bancs très-différents les unes des autres par leur aspect et par leur structure. La roche paraît être un mélange plus ou moins intime

The central portions of both ranges consist, mostly, of labradorite and hornblende; yet chlorite is also plentiful; and epidote—though of merely local occurrence—is often abundant. The structure, ordinarily, is crystalline; but distinct crystals of either principal ingredient are frequently imbedded, in masses of the other, and in mixtures of the rest.*

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d'amphibole hornblende et de feldspath labrador : ces minéraux sont parfois en cristaux distincts, parfois en grains imperceptibles."

RIVOT, *Annales des Mines,* 5me Série, VII. p. 225.

* Le greenstone est un trapp à texture cristalline, contenant beaucoup d'amphibole et de chlorite; la couleur de la roche est plus ou moins foncée, suivant la proportion assez variable du feldspath."—*Ibid,* p. 228.

"The summit of the Bohemian mountain * * * consists of chlorite and feldspar of a highly crystalline texture. * * * Beds [of trap] are found dipping from it like the strata of detrital rocks."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District,* I. p. 139.

"South of the *Phœnix* mine the feldspar predominates over the hornblende, giving the rock a light color. * * * The Albion range is capped with this rock, which appears in abrupt precipices two or three hundred feet in height. At the *Cliff* mine, the upper portion of the precipice is composed of dark crystalline greenstone—the hornblende largely predominating, which exhibits a mottled or varioloid appearance. At the *Albion* mine the feldspar again predominates, and the rock becomes in some degree porphyritic.—*Ibid,* pp. 64, 140.

"In a dark crystalline greenstone from the summit of the ridge at the *Cliff* mine, three distinct minerals were recognized; one is nearly colorless, or slightly tinged with green, and appears to be feldspathic, another is of a dark-green color, and resembles chlorite, while the third is apparently pyroxene or hornblende. Occasional crystals of magnetic iron occur.

"Its analysis as a whole gave

Silica	50·20
Alumina	15·43
Protoxide of iron	13·79
Lime	5·47
Magnesia	8·62
Soda	4·75
Water	1·74
	100.

"—*Ibid,* II. pp. 87—8.

"At the *Adventure* mine the rock is a hard, crystalline, greenstone, somewhat porphyritic, traversed by occasional strings and veins of calc-spar and epidote." *Ibid,* I. p. 141.

In composition the trap-rocks differ but little from the greenstones; except that chlorite may occur in larger, and hornblende in smaller, proportions; * calcareous-spar and oxydulated iron, however, appear in

* "At the *Northwest* mine in the same belt of trap in which are contained the *Cliff* and *North American* mines * * * the rock is a dark gray compact trap, occasionally amygdaloidal.—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 135.

"In township 56, range 32 * * * the trap consists of a reddish and greenish chlorite rock, with imbedded amygdaloid."—*Ibid*, p. 67.

"The only variety of trappean rock occurring in the Keweenaw Point range, in which the ingredients are distinctly visible, * * * we find to be made up of a light-red felspathic portion, having the character of labradorite, of a dark-green foliated mineral, which is probably pyroxene, chlorite and magnetic iron."
Ibid, II. p. 90.

"At the *Quincy* mine * * * the rock consists of a dark-brown chlorite trap, with beds of amygdaloid. Between the junction of these rocks native copper is observed in sheets."—*Ibid*, I. p. 65.

"Between Portage lake and the Fire-Steel river * * * the following varieties may be recognized;—

"*Compact-trap*—varying in color and texture, and occasionally taking into its composition a large proportion of chlorite, and a greenish magnesian mineral. Some varieties are exceedingly fine-grained and close in their texture * * *; others contain a very large percentage of magnetic oxide of iron. * * * The fluctuations of the needle often indicate the presence of the trappean rocks where they are effectually concealed by detritus and soil. * * *

"*Porphyritic trap*. The base of this rock consists of fine-grained trap, through which are diffused long and distinct crystals of white felspar. * * *

"*Epidote trap* occurs at many points especially in the vicinity of the Ontonagon river, occupying a space of several miles in length. The compact trap often passes gradually into it, the epidote replacing the hornblende. Seams of quartz and calc-spar containing copper are accompanied by epidote, which graduates on either side into compact trap."—*Ibid*, pp. 69, 70 (Abridged).

"At the *Minnesota* mine * * * the rock is a dark gray, mottled trap of a granular texture, with occasional almond-shaped cavities throughout it. It breaks into rhomboidal blocks, and readily yields under the drill. Its constituents are hornblende, feldspar, and chlorite."—*Ibid*, p. 134.

"La chlorite et le fer oxydulé entrent presque toujours en notable proportion dans la composition du trapp, et dans les cavités on trouve assez fréquemment des cristaux très-beaux de prehnite, d'analcime et d'épidote.

"La chlorite est souvent en proportion tellement forte, que le trapp paraît être un mélange de feldspath et de chlorite, renfermant très-peu d'amphibole."
Rivot, *Annales des Mines*, 5me Série, VII, p. 225.

notable quantities; * whilst epidote,—perhaps, associated with augite,†—exists, at intervals only, as before. Some portions are compact, others granular; ‡ but certain peculiarities of composition and structure, characterize each of the, rather ill-defined, beds § in this part of the system. The compact varieties, however, exhibit now and then traces of crystallization; ‖ but the granular layers often enclose,¶ though sometimes they pass into,** amygdaloid. Of this important

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* "Le fer oxydulé est presque toujours en petits cristaux discernables, quelquefois cependant on ne peut le distinguer à la vue simple; mais sa présence est toujours accusée par l'action énergetique produite sur l'aiguille aimantée. * * *

"L'épidote verte plus ou moins mélangée de quartz et de calcaire, se présente en masses considérables entre les bancs de trapp et pénètre à une assez grande distance dans la roche amygdaloïde. * * *

"Les cristaux définis d'épidote, de prehnite, d'analcime, etc., sont en relation avec les filons qui traversent le trapp; ils ont été rencontrés plus fréquemment à la pointe de Keweenaw que partout ailleurs." *Ibid*, pp. 225—6.

† "We may consider it to be demonstrated that augite is formed whenever the process of cooling, and consequently of crystallization, is rapid; and hornblende when it is conducted more slowly."—*Penny Cyclopædia*, III. (Augite), p. 85.

‡ "La structure des bancs de trapp présente de nombreuses variétés.—Certaines bancs sont compactes, très-durs et très-chargés d'amphibole; d'autres ont une texture grenue et contiennent beaucoup de feldspath, visible en cristaux blancs et roses; ils sont aussi durs que les premiers et ne sont pas considérés comme exerçant une bonne influence sur la richesse des filons."

RIVOT, *Annales des Mines*, 5me Série, VII. p. 226.

§ "The contour of the bedded trap is very different from that of the unbedded trap."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 64.

‖ "A l'est le trapp cristallin * * * est remplacé par le trapp compacte."

RIVOT, *Annales des Mines*, 5me Série, VII. p. 209.

¶ "Between Portage lake and the Montreal river * * * the amygdaloid is found irregularly scattered through the trap, but by no means so abundantly as west of the Ontonagon river."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 69.

** "On the north of the conglomerate belt [which extends from the eastern end of Keweenaw Point to the *Cliff* mine] the greenstone gradually becomes less

suite the different individuals closely resemble the trap-rocks respectively adjoining them,* in both structure and composition; except that they are frequently traversed by short and almost microscopic lines of tremolite or some similar mineral; and that reniform cavities, generally less than an inch in length, occur at unequal intervals throughout. Some of these are empty; but in various places many are lined or filled with either chlorite, felspar, quartz, prehnite, calcareous

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crystalline and compact. At length, by an imperceptible change, the rock is found to have become amygdaloid."

Whitney, *Metallic Wealth of the United States*, p. 257.

* "The base of the amygdaloidal trap is generally a fine-grained, homogeneous dark coloured mixture of hornblende and labrador, with numerous amygdules—some of which are an inch in their longitudinal direction—filled with different mineral substances. Between the Algonquin location and Agogebic lake, epidote frequently accompanies the amygdaloidal trap: west of the last-named place, it resembles more nearly the trap of Keweenaw Point, and is associated with large quantities of the zeolites. Where epidote fills the cavities, it presents a radiated, crystallized texture. * * * Generally the vesicles of the epidote are occupied by quartz, often radiated. The quartz is frequently coloured green by the presence of epidote.

"The zeolitic minerals often form so large a portion of the rock that it disintegrates and falls to pieces after a short exposure. At the *Atlas* location * * * they are so abundant that they are found not only in all the vesicles of the trap, but are distributed through it in large vein-like sheets."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. pp. 69—70.

"La variéte de trapp la plus remarquable est celle qu'on nomme l'amygdaloïde; elle est éminemment métallifère, c'est à-dire qu'elle encaisse les parties les plus riches des filons productifs explorés jusqu'à présent. Elle est en général de couleur très-foncée, agit fortement sur l'aiguille aimantèe, et présente de nombreuses cavités arrondies, communiquant entre elles par les fissures presque imperceptibles, remplies, * * * par des minéraux divers.

"C'est une roche bulleuse et finement fissurée, disposée en bancs plus irréguliers que ceux des autres variétés de trapp. * * * Les minéraux qui remplissent les cavités sont; le quartz, hyalin, l'agate, le feldspath, le calcaire blanc spathique, la chlorite fibreuse et rayonnée, l'épidote, la prehnite, l'analcime et même le cuivre natif.

"Chaque banc d'amygdaloïde a ses minéraux particuliers: à la pointe de

spar, epidote, zeolite, analcime, Laumonite, or native copper* often encrusted with virgin silver.

The conglomerates which frequently interlie, but are sometimes enclosed in, the trap-rocks,† consist of rounded, though often roughish, masses; of ordinary or amygdaloidal trap, for the most part;‡ but blocks of quartz-rock, enveloping small crystals of oxydulated iron, occur at intervals. The greenish, reddish, or chocolate-coloured cement in which they are imbedded, is, usually, trappean; but nests and thin strings of calcareous spar, and traces of siliceous

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Keweenaw, au nord et au sud du Greenstone, les noyaux sont principalement formés de chlorite, de quartz et de feldspath; au milieu de la zone métallifère du nord, un banc d'amygdaloïde a été pénétré par les matières des filons voisins, * * * ."

"Auprès du Portage et dans la contrée d'Ontonagon, la roche amygdaloïde est de même pénétrée par l'épidote, le calcaire, le quartz, la chlorite; le cuivre natif ne se présente que dans le voisinage immédiat des filons."

RIVOT, *Annales des Mines*, 5me Série, VII. p. 227.

* "At the *Northwestern* mine the shaft was sunk through a dark-brown amygdaloid, with little adhesion between the particles—the amygdules being filled in places with native copper, exhibiting occasional points of silver. Southward [this formation] is circumscribed by a belt of hard crystalline greenstone."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 138.

† "The conglomerate occurs in lentiform masses variable in number and thickness. On Keweenaw Point,—where they are numerous, possess much regularity, and range with the trap,—their united thickness exceeds five thousand feet. * * * In the Ontonagon district they are less numerous, but near the Montreal river they expand to an enormous thickness."—*Ibid*, p. 101.

"Limited belts are occasionally seen, but cannot be traced continuously for any considerable distance."—*Ibid*, p. 103.

‡ "Nodules of trap enter largely into the composition of the conglomerates."

BAYFIELD, *Quarterly Journal of the Geological Society*, I. p. 453.

"The conglomerate consists of rounded pebbles of trap, almost invariably of the variety known as amygdaloid, * * * and rounded fragments of a jaspery rock * * * the whole cemented by a dark-red iron sand. * * * It is not unusual to meet with strata composed entirely of arenaceous particles associated with the conglomerate beds; and where these expand to a considerable thickness the associated sandstone appears in alternating bands of white and red. The trappean pebbles often attain a magnitude of eighteen inches in diameter. Their surfaces do not present that smooth, polished appearance which results

matter, are not uncommon. Most of the kernels and much of their matrix, seem therefore to have had a common origin.*

The rocks of Keweenaw Point are traversed by two sets of joints; † one bearing a few degrees east of north and west of south, the other about east and west. Towards Ontonagon, however, the meridional series is less developed, but the nearly east and west joints are numerous.

The general directions of the trap-rocks, joints, and *lodes,* are shown on the opposite page.

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from the attrition of water. As we recede [from the trappean range] the amygdaloidal pebbles disappear, and are replaced by arenaceous and argillaceous particles."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District,* I. pp. 99—100.

"Les conglomérats contiennent des galets arrondis de toute grosseur, de trapp compacte, amygdaloïde, cristallin, porphyritique et de jaspe, c'est à-dire de toutes les roches dures autres que le granite existant dans la contrée; ils sont empâtés dans un ciment compacte qui paraît être composé des mêmes matières. Les grès subordonnés dont les couches sont comprises dans la formation des conglomérats, sont formés de grains de quartz et de feldspath, dans un ciment ferrugineux. * * *

"En observant attentivement les galets arrondis des conglomérats, on distingue des fissures très-fines, remplies par du calcaire spathique, qui paraissent se continuer dans la pâte.

"Aucun fossile n'a encore été signalé dans les conglomérats * * * ."

Rivot, *Annales des Mines,* 5me Série, VII. pp. 228—9.

* "The appearance of the conglomerate is seen to be allied with, and subordinate to, that of the igneous masses; and it appears to have been a result of the combined action of the two classes of agencies by which the trap and the sandstone were formed."

Whitney, *Metallic Wealth of the United States,* p. 253.

"Les lits de conglomérats et de grès qui séparent les bancs de trapp, les alternances que présente la partie supérieure de la formation trappéenne, et principalement l'immense étendue et la régularité de ces alternances, semblent indiquer que les trapps ont été produits en même temps que la formation sédimentaire et non pas postérieurement aux dépôts des couches."

Rivot, *Annales des Mines,* 5me Série, VII. p. 234.

† "The main [joints] fissures pursue a course varying but a few degrees "from the * * * meridian.—Foster & Whitney, *Report on the Geology of the Lake Superior Land District,* I. p. 108.

Directions of the Trap-range, Joints, and *Lodes*, in the Districts of Keweenaw and Ontonagon.

Nature of rock.	Directions of Trap-range, Joints, and *Lodes*.	N. & S.—15° E. of N. & W. of S.	15°—30° E. of N. & W. of S.	30° E. of N. & W. of S.—N.E. & S.W.	N.E. & S.W.—30° N. of E. & S. of W.	30°—15° N. of E. & S. of W.	15° N. of E. & S. of W.—E. & W.	E. & W.—15° S. of E. & N. of W.	15°—30° S. of E. & N. of W.	30° S. of E. & N. of W.—S.E. & N.W.	S.E. & N. W.—30° E. of S. & W. of N.	30°—15° E. of S. & W. of N.	15° E. of S. & W. of N.—N. & S.	Means.	Numbers of observations. Representative.	Numbers of observations. Total.
	Keweenaw.															
Trap ..	Trap-range..	—	—	*	*	*	—	—	—	—	—	—	—	N.E. & S.W.†	—	—
	Joints	0·70	0·07	—	0·07	—	—	0·10	0·06	—	—	—	—	—	1	30 ‡
	Lodes	0·07	0·18	—	—	—	0·03	—	0·04	0·04	0·04	0·46	0·14	29° S. of E. & N. of W. §	1	28 ‖
	Ontonagon.															
Trap ..	Trap-range..	—	—	—	*	*	*	—	—	—	—	—	—	15°—25° N. of E. & S. of W.†	—	—
	Joints	—	0·14	—	0·14	0·14	—	0·44	—	—	0·14	—	—	—	1	7
	Lodes	0·04	0·24	—	0·24	0·15	0·27	0·06	—	—	—	—	—	37° N. of E. & S. of W.	1	33 ‖

* Direction of the Trap-range in different parts of its course. † *Ante*, p. 395.

‡ Hill (Foster & Whitney's) *Report on the Geology of the Lake Superior Land District*, I. p. 108.

§ These results are deduced from observations by Messrs. Foster & Whitney (*Report on the Geology of the Lake Superior Land District*, I. pp. 127—51; III. pp. 760—4); Mr. Whitney (*Metallic Wealth of the United States*, pp. 262—301); and M. Rivot (*Annales des Mines*, 5me Série, VII. pp. 245—326); as well as from my own.

‖ The magnetic variation near Lake Superior in 1847 was 5° 35′ East.—Whittlesey (Foster & Whitney's), *Report on the Geology of the Lake Superior Land District*, II. p. 346. *Ante*. p. 395, Note §.

Owing to flexures of the principal trap-range, continuous portions in the neighbouring metalliferous districts differ in direction * somewhat more than .... 22°.

Meanwhile the *lodes* which traverse it at Keweenaw Point, vary in *strike* † from those which interlie it at Ontonagon, no less than .... 66°.

At Keweenaw Point the angles included ‡ by the *lodes* and trap-rocks average about 74°.

Near Ontonagon „ § „ „ 17°.

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* Foster & Whitney, *Geological Map of the Lake Superior Land District.* Whitney, *Metallic Wealth of the United States,* p. 252. Rivot, *Annales des Mines,* 5me Série, VII. pp. 210, 215. *Ante,* p. 395.

† The directions of the *lodes* in different parts of Cornwall and Devon, average—

Saint Just	35° N. of W.
Saint Ives	8° N. of W.
Marazion	1° S. of W.
Gwinear, &c.	2° N. of W.
Helston	16° S. of W.
Camborne	20° S. of W.
Redruth, Gwennap, and St. Agnes	22° S. of W.
Saint Austell	13° S. of W.
Tavistock, &c.	9° S. of W.
Mean	4° S. of W.

Henwood, *Cornwall Geol. Trans,* V. p. 250.

‡ " On Keweenaw Point one system of veins is well defined. Their bearing is north of west—the mean of several observations giving north 21½ west. So true is this, that no permanently productive vein has been discovered thus far which varied 15° from this course, which is at nearly right angles to the formation."—Foster & Whitney, *Geological Report on the Lake Superior Land District,* I. p. 167.

" Dans la région qui s'étend depuis l'extrémité orientale de la Pointe jusqu'à la mine Albion, les filons transversaux sont extrêmement nombreux, leur distance ordinaire paraît comprise entre 200 et 600 mètres, et tous sont à peu près perpendiculaires à la direction du trapp : quelques-uns paraissent faire exception et couper les bancs sous un angle plus ou moins aigu ; mais en les étudiant avec attention, on peut reconnaître qu'ils sont des veines détachées d'un filon principal ou qu'ils ne s'étendent en diagonale qu'entre deux filons normaux."

Rivot, *Annales des Mines,* 5me Série, VII. p. 249.

§ " In the Ontonagon region * * * the veins run with the formation instead of cutting it at right angles, like those of Keweenaw Point."— Foster & Whitney, *Geological Report on the Lake Superior Land District,* I. p. 168.

" The mode of occurrence of the cupriferous deposits of the Ontonagon

All *lodes* exhibit many flexures;—as well vertical as horizontal;* and in some instances they have different bearings† in the same neighbourhoods.

The following columns show the extreme and average dips of *lodes* having different directions.‡

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region differs materially from that exhibited by the veins of Keweenaw Point. They are characterized by a constant parallelism with the line of strike of the formation."—Whitney, *Metallic Wealth of the United States*, p. 286.

"Tous les gisements explorés jusqu'à présent [dans le contrée d'Ontonagon], sont dans le trapp, et sont parallèles, en direction, aux terrains."
Rivot, *Annales des Mines*, 5me Série, vii. p. 267.

* "At the *Cliff* mine belts of rock form parts of great curves, not sensibly differing from straight lines in short distances, but whose divergence must be quite perceptible in an extent of 500 feet.
Whitney, *Metallic Wealth of the United States*, p. 277.

† At *Lac la Belle* mine two sets of veins have been observed—one bearing north 26½° west, which appear to be the main ones, and another bearing north 80° east."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 139, 148—9.

At *Copper Falls* "several veins are nearly parallel with each other, their course being north 22° to 25° west. They have, in almost every case, been traced across the whole width of the belt of trap north of the greenstone, a distance of more than a mile. * * * Two of these—the Copper Falls and Hill—veins only have been worked to any extent. * * *

"In this mine a remarkable feature has been discovered, which is unlike anything yet noticed on Point Keweenaw. This is the occurrence of a metalliferous bed included in the formation, and parallel with it. This stratum, which has been intersected in the works on both *lodes*, is about 100 feet thick; and a fissure * * * between it and the overlying bed,—a bluish granular trap,—is filled with veinstone. This east and west vein is distinctly worked on the surface at the *Copper Falls* mine, where it contains small bunches of copper. The bed underlying it * * * is of a brownish color, quite soft, and everywhere filled with copper."—Whitney, *Metallic Wealth of the United States*, pp. 264—5.

Rivot, *Annales des Mines*, 5me Série, vii. pp. 265, 297—304.

‡ Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. pp. 127—151; iii. pp. 760—4. Whitney, *Metallic Wealth of the United States*, pp. 262—301. Rivot, *Annales des Mines*, 5me Série, vii. pp. 245—326. *Ante*, p. 405, Note §.

Dips.	Directions.												Dips.		
	N. to N.E.— S. to S.W.			N.E. to E.— S.W. to W.			E. to S.E.— W. to N.W.			S.E. to S.— N.W. to N.			Extremes		Means
	G.*	S.*	M.*	G.	S.	M.	G.	S.	M.	G.	S.	M.	G.	S.	
KEWEENAW.															
N.—N.E.	..	..	..	..	..	..	82°	80°	81°†‡	..	..	..	82°	80°	81°
N.E.—E.	..	..	..	..	..	..	..	..	..	86°	60°	77°§	86°	60°	77°§
E.—S.E.	88°	79°	84°	..	..	..	..	..	..	..	..	..	88°	79°	84°
S.E.—S.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.—S.W.	..	..	..	..	..	..	..	..	82°†‡	..	..	..	..	..	82°†‡
S.W. W.	..	..	..	..	..	..	..	..	..	85°	65°	77°§	85°	65°	77°§
W.—N.W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
N.W.—N.	..	..	..	..	..	55°†	..	..	..	..	..	..	..	..	55°†
Extremes..	88°	79°	..	..	..	..	82°	80°	..	86°	60°	..	88°	55°	..
Means ..	..	..	84°	..	..	55°†	..	..	81°	..	..	77°	..	..	77°
ONTONAGON.															
N.—N.E.	..	..	..	..	..	..	65°	23°	48°	..	..	..	65°	23°	48°
N.E.—E.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E.—S.E.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.E.—S.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.—S.W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.W.-W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
W.—N.W.	85°	42°	70°	..	..	..	..	..	..	..	..	..	85°	42°	70°
N.W.—N.	..	..	..	70°	42°	55°	..	..	..	..	..	..	70°	42°	55°
Extremes..	85°	42°	..	70°	42°	..	65°	23°	..	..	..	..	85°	23°	..
Means ..	..	..	70°	..	..	55°	..	..	48°	..	..	..	..	..	56°

* G., S., M.,—Greatest,—smallest,—mean. † Single observations.

‡ *Lodes* having similar directions, but opposite dips.

§ ,, ,, , ,, .

The *lodes* of Keweenaw Point have, therefore, an average dip of 77°; *—
but those near Ontonagon „ „ 55° † only.
Of 53 *lodes* in the Keweenaw district, 37 (0·7) have an easterly,
„ „ and 16 (0·3) a westerly dip,
whilst 65 „ at Ontonagon............. (1·0) all dip towards the north.

Other obvious influences scarcely need recapitulation.

The following columns set forth the extreme and average widths of *lodes* having different directions and dips.

Dips.	Directions. N. to N.E.—S. to S.W. Widths. feet G.‡	feet S.‡	feet M.‡	N.E. to E.—S.W. to W. Widths. feet G.	feet S.	feet M.	E. to S.E.—W. to N.W. Widths. feet G.	feet S.	feet M.	S.E. to S.—N.W. to N. Widths. feet G.	feet S.	feet M.	Widths. feet G.	feet S.	feet M.
						KEWEENAW.									
N.—N.E.	..	..	..	..	..	..	7·0	1·0	3·0‖	..	..	..	7·0	1·0	3·0‖
N.E.—E.	..	..	..	..	..	..	..	..	..	7·0	0·6	2·2¶	7·0	0·6	2·2¶
E.—S.E.	9·7	0·5	2·3	..	..	..	..	..	..	..	..	..	9·7	0·5	2·3
S.E.—S.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.—S.W.	..	..	..	..	..	..	3·0	1·0	2·§‖	..	..	..	3·0	1·0	2·0§‖
S.W.—W.	..	..	..	..	..	..	..	..	..	6·5	0·3	2·2¶	6·5	0·3	2·2¶
W.—N.W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
N.W.—N.	..	..	..	..	..	0·6§	..	..	..	..	..	..	..	..	0·6§
Extremes..	9·7	0·5	..	..	..	..	7·0	1·0	..	7·0	0·3	..	9·7	0·3	..
Means ..	..	..	2·3	..	..	0·6§	..	..	3·0	..	..	2·2	—	..	2·4

" * The dip of most of the veins in this district is nearly perpendicular, and generally pretty regular, the underlay, or deviation from a vertical line, being rarely more than 8 or 10 degrees."

WHITNEY, *Metallic Wealth of the United States*, p. 260.

† At Ontonagon " true veins coincide in direction with the beds of rocks, but dip at a different, and usually a greater angle, in the same direction with the formation."—*Ibid*, p. 287.

‡ G., S., M. Greatest,—smallest,—mean. § Single observations.

‖ *Lodes* having similar directions, but opposite dips.

¶ „ „ , „ .

Dips.	Directions. N. to N.E.—S. to S.W. Widths.			N.E. to E.—S.W. to W. Widths.			E. to S.E.—W. to N.W. Widths.			S.E. to S.—N.W to N. Widths			Widths.		
	feet G.	feet S.	feet M.	feet G.	feet S.	feet M.	feet G.	feet S.	feet G.	feet G.	et S.	feet M.	feet G.	feet S.	feet M.
							ONTONAGON.								
N.—N.E.	..	..	..	..	..	..	2·5	0·2	2·2	..	..	..	2·5	0·2	2·2
N.E.—E.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E.—S.E.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.E.—S.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.—S.W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S.W.—W.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
W.—N.W.	16·	0·3	4·5	..	..	..	..	..	..	..	..	..	16·0	0·3	4·5
N.W.—N.	..	..	..	12·	0·2	3·1	..	..	..	..	..	..	12·0	0·2	3·1
Extremes..	16·	0·3	—	12·	0·2	..	2·5	0·2	..	..	..	..	16·0	0·2	..
Means ..	..	..	4·5	..	..	3·1	..	..	2·2	..	..	..	..	..	3·2

The *lodes* in Keweenaw Point, therefore, average 2·4 feet in width;
those near Ontonagon „ „ 3·2 „ „

The following columns afford a comparison of the mean directions, dips, and widths, of the *lodes* in different districts.*

	Directions.	Dips.	Widths. feet.
Keweenaw.........	29° S. of E. & N. of W.† ...	77° ‡ ...	2·4 §
Ontonagon	37° N. of E. & S. of W.† ...	56° ‡ ...	3·2 §

* The average directions, dips, and widths of *lodes*, and *cross-veins* in Cornwall and Devon are—

	Directions.	Dips.	Breadths. feet.
Lodes..........	4° N. of E. & S. of W.	about 70°	3·61
Cross-veins	38° S. of E. & N. of W.	„ 80°	4·03

Henwood, *Cornwall Geol. Trans.*, v. pp. 247, 250, 277, 279, *Tables CI., CIII., CIV., CVI.; Ante*, p. 309.

† *Ante*, p. 405. ‡ *Ibid*, p. 407. § *Ibid*, p. 409—*Supra.*

The ingredients of the *lodes*, and their relations to those of the adjoining rocks, may be conveniently described together.

Keweenaw Point.

(*a.*) Immediately north of the crystalline greenstone,* some two miles and a half south-east of Eagle river, the *Meadow* mine has been opened in a coarse, granular trap-rock, composed chiefly of labradorite and hornblende, but containing also much chlorite.† Small, isolated, masses of quartz occur at intervals; and short, thin, lines of calcareous-spar,—mixed sometimes with epidote—here and there traverse the other constituents. A few of the beds—which are seldom well defined—show traces of amygdaloidal structure.

Within a width of forty fathoms three *lodes* were (in 1852) wrought ‡ to a depth of about thirty feet; viz.—

	North, or North-east, vein.	*Middle vein.*	*South, or South-west.*
Directions.	.. 25°—45° W. of N.—E. of S.	25° W. of N.—E. of S.	25° W. of N.—E. of S.
Dips	.... S.—S.W. 68°—70°	N.—N.E. 65°—70°.	S.—S.W. 66°—75°.
Widths ..	one vein .. 1·0 — 1·5 foot. two veins.. 0·6 & 0·8 „	.... 2·5 feet	0·6—0·8 foot. A line.

In all these the most abundant ingredient is trap; which sometimes encloses, but is frequently enclosed

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* Whitney, *Metallic Wealth of the United States*, p. 255. *Ante*, p. 328.

† *Ante*, pp. 399, 401.

‡ In 1853 four veins were wrought.—Whitney, *Metallic Wealth of the United States*, p. 266.

in, quartz or calcareous-spar. These now and then occur separately; but more commonly they are mingled, though unequally in different places. Smaller quantities of chlorite are scattered amongst the other minerals; epidote appears from time to time; and in narrow parts of the *lodes* Laumonite prevails. Mammillary concretions of prehnite often incrust the granules, threads, plates, and masses of native copper; which are numerous in the calcareo-siliceous portions; especially where the neighbouring *(Country)* rock is of amygdaloidal character.

The directions of these, as well as of many other *lodes*, both in Keweenaw Point* and at Ontonagon,* may be traced by ranges of cuttings † and heaps of

* "Upon Keweenaw Point ancient pits have been found extending from Eagle-river eastward, a distance of twelve miles, along the base of the trap range.

"For a distance of nearly thirty miles [in the Ontonagon district] there is almost a continuous line of [similar works] along the middle range of trap, though they are not exclusively confined to it."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 161.

"Throughout the whole extent of the copper region, from the extremity of Keweenaw Point to a considerable distance beyond the Ontonagon, * * * numerous excavations made for the purpose of procuring copper have been found."—Whitney, *Metallic Wealth of the United States*, p. 250.

"Les vieux travaux sont nombreux au nord et au sud du greenstone, dans le district de la pointe de Keweenaw; ils sont plus nombreux et plus importants dans la contrée d'Ontonagon, à l'est et à l'ouest de la rivière."

Rivot, *Annales des Mines*, 5me Série, VII. p. 280.

† The *Cliff* vein "has been traced to the Lake, and found marked by ancient excavators."—Whitney, *Metallic Wealth of the United States*, p. 265.

"During the winter of 1847—8 it was discovered that [at the location since occupied by the *Minnesota* Company] mining operations had been carried on many hundred years previously. * * * A series of open cuts had been made along the brow of the hill, * * * from which had been taken large quantities of rock, and probably of copper." The line "of ancient excavations was quite perceptible, even under a covering of three feet of snow;" * * * notwith-

rubbish,* the works of an earlier race of miners. A few of these ancient openings exceed twenty feet in depth,† but many are less than ten; ‡ traces of copper are visible in most of them, but the largest masses have generally been found in the deepest pits.§ Exhausted

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standing, "they were, in great measure, filled with an accumulated mass of clay, sand, and mouldering vegetable matter."

JACKSON, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 745. WHITNEY, *Metallic Wealth of the United States*, p. 293.

"Near the *Copper Falls* Mine there are extensive ancient workings on a metalliferous belt; which is of a brownish color, quite soft, and everywhere filled with copper."—WHITNEY, *Metallic Wealth of the United States*, p. 265.

"At the *Forest* Mines very extensive excavations had been made by the ancient miners, and quite large masses of copper were found near the surface in cleaning out the old workings, of which there are four parallel rows along the bluff."

Ibid, p. 297.

Squier & Davis, *Smithsonian Contributions to Knowledge*, I. pp. 279—81. Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 159. Henwood, *Reports of the Royal Institution of Cornwall*, XXXV. (1853) p. 22. Rivot, *Annales des Mines*, 5me Série, VII. pp. 278—82.

* "The rubbish taken from the mine is piled up in mounds, which can readily be distinguished from the former contour of the ground."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, p. 159.

† At the *Minnesota* mine "one of the ancient excavations was found to be 26 feet deep on the vein," and at the *National* Mine "a shaft had been sunk in former times, to a depth of about 50 feet, on the lode."

WHITNEY *Metallic Wealth of the United States*, pp. 293, 297.

‡ "Les vieux travaux sont arrêtés à une faible profondeur, de 3 à 12 mètres, suivant la configuration des terrains, et n'ont pas été poussés plus bas à cause des eaux."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 280.

§ When the earlier works at *Minnesota* were reopened "to a depth of 18 feet, a mass of native copper ten feet long, three feet wide, nearly two feet thick, and weighing over six tons, was met with. It had been raised about five feet from its native bed by the ancient miners, secured there on oaken props, and abandoned apparently on account of the difficulty of raising it to the surface. Every projecting point which was accessible had been taken off, so that the exposed surface was smooth. Below this the vein was subsequently found filled with a sheet of

works are often filled with broken vein-stone.*

Egg-shaped and reniform masses of greenstone, porphyry, and quartzose-sandstone, in all which deep grooves have been cut—probably for the reception of withes or thongs, to secure, or to serve as, hilts,—lie scattered, either singly or in groups, amongst the rubbish,†—as well in the underground works as at the surface—of every mine in both districts. They

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copper five feet thick, and of undetermined extent vertically and longitudinally."

JACKSON, *Report on the Geological, and Mineralogical Survey of Lands in Michigan*, III. p. 745. FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 159. WHITNEY, *Metallic Wealth of the United States*, p. 293.

"On cleaning out an ancient shaft which had been sunk to the depth of about 50 feet at the *National* Mine, the remains of *stulls* or timbers forming a scaffolding, and a nearly continuous sheet of copper, were found."

WHITNEY, *Metallic Wealth of the United States*, p. 297.

"At the *Central* Mine, not far from Eagle Harbor, a mass of copper was found in one of the old pits that weighed forty-six tons."

Atlantic Monthly Magazine, XV. (March, 1865) p. 310.

* "These primitive workmen seem not to have lifted their rubbish to the surface, but to have thrown it behind them; thus filling their abandoned works as they proceeded."—HENWOOD, *Reports of the Royal Institution of Cornwall*, XXXV. (1853), p. 22.

"At the *Minnesota* Mine an ancient opening was found to have been filled with rubbish as the miners advanced." WHITTLESEY (Lecture at Montreal), *Lake Superior Miner*, III. (12th September, 1857) p. 2.

† "Large quantities of stone hammers, or boulders of an ovoidal shape, with a groove cut around them near the middle, probably for the purpose of attaching a handle with a withe, were found buried in the rubbish which filled many ancient works at the *Minnesota* Mine. * * * Furthermore we found half-finished scalping-knives and spear-heads in the soil near the Eagle river copper mine; and those instruments bear ample evidence of their Indian origin."—JACKSON, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. pp. 374, 745.

"The amount of ancient hammers found in the vicinity of the *Minnesota* Mine exceeded ten cart-loads. * * * They are made of greenstone or porphyry pebbles, with a groove, single or double, cut around, by which a withe was attached. One of the larger class weighed 39½ lbs.; smaller specimens were of 5 or 6 lbs. each.

"In addition to these relics a copper *gad*, with the head much battered, and

weigh mostly from six to eight pounds each, but some are much heavier. Notwithstanding they are the hardest pebbles amongst the *drift*, in the beds of rivers, and on the lake-shores, many of them appear chipped by use. Knives, spear-heads, a *gad* (wedge), and a chisel of hammered copper; beside a broken bowl and some shovels of wood; have been discovered, from time to time, in and near the mines.

From the presence of wood-ashes in the works, it has been inferred that fire was occasionally used* to soften the rock.

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a copper chisel, with a socket for the reception of a handle, were brought to light. * * *

"In cleaning out one of the pits at the *Forest* mine at a depth of ten feet the workmen came across a fragment of a wooden bowl * * * ."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 160—1.

Squier & Davis, *Smithsonian Contributions to Knowledge*, I. p. 280. Henwood, *Reports of the Royal Institution of Cornwall*, XXXV. (1853) p. 23, *Fig.* 1, 2. Whitney, *Metallic Wealth of the United States*, p. 250. Rivot, *Annales des Mines*, 5me Série, VII. p. 279. Lapham, *Smithsonian Contributions to Knowledge*, VII. pp. 74—7. Whittlesey, *Lake Superior Miner*, III. (12th September, 1857) p. 2. *Atlantic Monthly Magazine*, XV. (March, 1865) pp. 308—10.

* "Remnants of charcoal were found, at numerous places, lying on the surface of the rock."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 161.

"Fragments of charcoal have been often noticed, indicating that the method pursued was similar to that still employed in some of the European mines, in the use of fire to attack the rock."

WHITNEY, *Metallic Wealth of the United States*, p. 250.

"The mode of mining pursued by the aborigines was to build fires to soften the rock, and then break out the metal by means of stone hammers."

WHITTLESEY (Lecture at Montreal), *Lake Superior Miner*, III. (12th September, 1857), p. 2.

Squier & Davis, *Smithsonian Contributions to Knowledge*, I. p. 280. Rivot, *Annales des Mines*, 5me Série, VII. p. 280. *Atlantic Monthly Magazine*, XV. (March, 1865) p. 311. *Ante*, pp. 51—2.

Pines two or three feet in diameter were still growing on ancient heaps of rubbish, at the *Meadow* mine in 1852; and yet older and larger trees, covered the earlier works of other mines.*

From the extent of the earlier works,† and from the numbers of rude, yet serviceable, tools still remaining,‡ it may be inferred that a large population was once engaged in searching for copper;—the depths of numerous pits § show that—in them at least—operations were long continued;—and that many were abandoned several centuries ago is shown by the ages of the trees ||

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* "At the *Vulcan* mine extensive open cuts, made by the ancient miners, have been filled nearly to a level by the accumulation of soil, and we find trees of the largest growth standing in the depressions; and also find that trees of a very large size have grown up and died, and decayed many years since: in the same places there are now standing others of over three hundred years' growth."
Squier & Davis, *Smithsonian Contributions to Knowledge*, i. p. 280.

"Upon an [artificial] mound of earth we saw a pine stump, broken fifteen feet from the ground, ten feet in circumference, which must have grown, flourished, and died since the earth in which it had taken root was thrown out. Mr. Knapp [of the *Minnesota* mine] counted three hundred and nine-five annular rings on a hemlock, growing under similar circumstances, which he felled near one of his shafts. Thus it would appear that these exploitations were made before Columbus started on his voyage of discovery."
Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 160.

"There is plenty of evidence that the timber of full size, now flourishing in the old excavations, is of the second growth at least since the mines were deserted. * * * It must not be forgotten, however, that the same species of tree does not immediately succeed, but those of other kinds take its place."
Whittlesey (Lecture at Montreal) *Lake Superior Miner*, iii. (12th September, 1857) p. 2. (Abridged.)

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, iii. p. 745. Henwood, *Reports of the Royal Institution of Cornwall*, xxxv. (1853) p. 22. Whitney, *Metallic Wealth of the United States*, p. 250. Rivot, *Annales des Mines*, 5me Série, vii. p. 279. Lubbock, *Pre-Historic Times*, p. 202. *Atlantic Monthly Magazine*, xv. (March, 1865) p. 311.

† *Ante*, p. 412. ‡ *Ibid*, p. 414. § *Ibid*, p. 413. || *Supra*.

found rooted in the broken vein-stone and other rubbish with which they were mostly filled;* but whether all were wrought at the same time,† or by the same people,‡ is unknown.

Notwithstanding the extent and richness of the ancient mines,§ the tools and weapons of copper, yet discovered in and near them, have been very few; ||

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* *Ante*, p. 414.

† "Dans toute la contrée dans laquelle les explorations récentes ont signalé le cuivre natif, on a constaté l'existence d'anciens travaux d'exploitation: * * * en d'autres points les excavations paraissent bien plus modernes, et abandonées tout récemment." RIVOT, *Annales des Mines*, 5me Série, VII. p. 279.

"From the amount of work accomplished by the ancient miners, and their want of facilities, their operations must have extended through a period of five hundred years. From the fact that no remains of houses in that severe climate are found, no roads or other improvement made by permanent inhabitants, the conclusion seems inevitable that the mines were wrought only in summer, and that by some people who came hither for the purpose, and departed with the approach of winter."— WHITTLESEY (Lecture at Montreal), *Lake Superior Miner*, III. (12th September, 1857) p. 2.

Atlantic Monthly Magazine, XV. (March, 1865) p. 312.

‡ "All will assign to these excavations a high antiquity; but whether they were made by a race distinct from the Indian now inhabiting the region, is a matter of extreme doubt."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 162.

"No remains of habitations or burial-places, which might furnish a clue to the race by which this work was done, have yet been found."

WHITNEY, *Metallic Wealth of the United States*, p. 250.

"En rapprochant ces faits des renseignements rapportés par les missionnaires jésuites et les plus anciens voyageurs, on peut conclure que les mines de cuivre natif ont été de tout temps exploitées par les Indiens peaux rouges, résidant, en faisant seulement des excursions dans la contrée."

RIVOT, *Annales des Mines*, 5me Série, VII. p. 280.

"Upon a general consideration of the earth-works in Wisconsin, we are led to the inference that the men who built them, and those who first opened the Lake Superior copper mines, were one and the same people; and that they were none other than the ancestors of the present race of Indians."

LAPHAM, *Smithsonian Contributions to Knowledge*, VII. p. 26.

Atlantic Monthly Magazine, XV. (March, 1865) p. 312.

§ *Ante*, p. 413. || *Ibid*, p. 415.

but from aboriginal earthworks in Wisconsin,* Ohio,† and Canada ‡ also, axes,§ chisels,|| borers,¶ tubes,** knives,††, spear-heads,‡‡ arrow-heads,§§ bracelets,|||| gorgets,¶¶ buttons,*** and beads ††† are, from time, obtained. The metal, generally, is remarkable for its purity ; ‡‡‡ but now and then granules of native silver are embedded in the copper,§§§—a mode of association peculiar to this region.

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* Lapham, *Smithsonian Contributions to Knowledge*, VII. pp. 1-92. Whittlesey (Lecture at Montreal), *Lake Superior Miner*. III. (12th September, 1857) p. 2. *Atlantic Monthly Magazine*, XV. (March, 1865) p. 312.

† Squier & Davis, *Smithsonian Contributions to Knowledge*, I. pp. 1—306. Whittlesey, *Lake Superior Miner*, III. p. 2. *Atlantic Monthly Magazine*, XV. p. 312.

‡ Squier & Davis, *Smithsonian Contributions to Knowledge*, I. p. 201.

§ *Ibid*, I. p. 197, *Fig.* 81, 82.

|| Lapham, *Ibid*, VII. p. 88, *Fig.* 60.

¶ Squier & Davis, *Ibid*, I. p. 200, *Fig.* 85.

** *Ibid*, I. p. 207, *Fig.* 93.

†† *Ibid*, I. pp. 201—2, *Fig.* 87—3.

‡‡ *Ibid*, pp. 201—2, *Fig.* 86—1, 2 ; 87—1, 2.

§§ Lapham, *Ibid*, VII. p. 77, *Fig.* 3, 4.

|||| Squier & Davis, *Ibid*, I. p. 204, *Fig.* 88.

¶¶ *Ibid*, I. pp. 205—6, *Fig.* 89, 90.

*** *Ibid*, I. p. 207, *Fig.* 94.

††† *Ibid*, I. p. 207, *Fig.* 96.

‡‡‡ " The axes were found, upon analysis, to be *pure copper*,—unalloyed, to any perceptible extent, by other metals."—*Ibid*, I. p. 202.

" A slice of copper from the great mass at the *Copper Falls* mine, was found on analysis to be pure copper. * * * A strip from one of the largest masses at the bottom of the *Cliff* mine was dissolved in pure nitric acid, and left * * * but a minute portion of silex. * * *

" A piece sawn out of a large crystal from the *Cliff* mine when dissolved in pure nitric acid and distilled in water left scarcely 0·00107 its weight of silex."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. pp. 475—6.

§§§ As the copper discovered in ancient mounds of earth " is occasionally found combined with silver in the peculiar manner characterizing the native deposits

All these tools, weapons, and ornaments, however, are of native copper; for—notwithstanding the earlier miners often applied fire to the rocks,*—no trace of molten † metal has been found either in the earthen mounds or in the mines.

(*b.*) The *North American* mine (*Table XI.*), about three miles and a half south-west of Eagle river,

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upon the shores of Lake Superior, we are led to conclude that it was principally, if not wholly, derived from that region."

SQUIER & DAVIS, *Smithsonian Contributions to Knowledge*, I. p. 279.

"In the copper tools found in Ohio, are seen spots of native silver; a fact well known in relation to Lake copper."

WHITTLESEY, *Lake Superior Miner*, III. p. 2.

"In these copper relics, blotches and grains of native silver are found."

Atlantic Monthly Magazine, XV. p. 309.

"The native silver is scattered through the metallic copper, of the Lake Superior region, in such a manner that each metal remains entirely free from alloy with the other, although the junction of the two at their edges is a perfect one."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 178.

"In the Lake Superior veins native silver occurs intimately united with copper, being, as it were, soldered to it, or forming blotches and specks within it, but the two metals are never found alloyed together."

WHITNEY, *Metallic Wealth of the United States*, p. 278.

Rivot, *Annales des Mines*, 5me Série, VII. p. 314.

* *Ante*, p. 415.

† "Considerable quantities of wrought, and some small fragments of unwrought native copper, have been extracted from the mounds. * * * The metal appears, in all cases, to have been worked in a cold state."

SQUIER & DAVIS, *Smithsonian Contributions to Knowledge*, I. p. 279.

"There is no evidence that the race by whom the tumuli were built possessed sufficient knowledge of the metallurgic art to reduce and purify the ores of copper."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 158.

"The Ohio people of the Mound Epoch did not possess the art of smelting copper."—WHITTLESEY, *Lake Superior Miner*, III. p. 2.

Lubbock, *Pre-Historic Times*, p. 418.

"I have never seen a copper relic [from this region] that had the appearance of having been melted. They invariably appear to have been cut and hammered into shape from masses of native copper."

Atlantic Monthly Magazine, XV. p. 309.

has been wrought in the granular and amygdaloidal trap immediately south-east of the greenstone, to a depth of nearly seventy fathoms, on a *lode* which bears 38°—45° S. of E.—N. of W,—dips 60°—85° N.E.,—and varies, from less than an inch to about six feet, in width.* On the north-east, however, two nearly parallel, though subordinate *(branches)*, veins unite with it at different *levels*: † but neither of them has been traced through the greenstone.‡

Their more abundant ingredients are calcareous-spar, quartz, and prehnite; but Laumonite, chlorite, epidote, hornblende, and disintegrated felspar (? labradorite),—though generally present §—occur in smaller quantities. Most of them are more or less mixed; but—here and there—one or other is separately aggregated. Sometimes, also, blocks of trap are imbedded in and transfused with the other components of the vein-stone. A cellular structure—oblique to both the

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* Jackson, Foster, & Hill, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. pp. 458, 760. Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I pp. 132, 146. Whitney, *Metallic Wealth of the United States*, p. 279. Rivot, *Annales des Mines*, 5me Série, VII. p. 315.

† "Near the 155 foot level a small vein or feeder unites with the lode, [which immediately] below increases in width, and becomes highly metalliferous. At a depth of 275 feet another feeder comes in, and, like the former—enriches and expands the lode still further."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 132; Whitney, *Metallic Wealth of the United States*, p. 277.

‡ "The vein was not exposed in the face of the cliff."—Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 458.

§ "The vein-stone consists of calc-spar, laumonite, prehnite, chlorite, apophyllite, and drusy quartz."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 146.

dip and direction of the *lode*—is assumed, at intervals, by portions in which every cavity is encrusted with minute crystals of quartz.

Fig. 26. THE NORTH AMERICAN MINE.

Massive and cellular quartz sprinkled with native copper.

Natural size.

Longitudinal joints frequently divide the *lode* into parallel *(combs)* slices,* which are now and then characterized by either the proportions or the disposition of their constituents.

Wherever the adjoining *(Country)* rock is of amygdaloidal structure, the *lode* contains native-copper; usually in grains and small lumps,† but occasionally

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* Boase, *Primary Geology*, p. 179. Burr, *Mining Review*, III. (1836) p. 237. Fox, *Report of the Royal Polytechnic Society of Cornwall*, IV. (1836) p. 89. De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 339. Henwood, *Cornwall Geol. Trans.* V. p. 179.

† "Through the entire length of the lower level [180 feet from the surface] the lode has been found good, containing in some places mass copper. From an examination at the depth of 95 feet, it is inferred that the veinstone is 3 or $3\frac{1}{2}$ per cent. richer than that taken from the second level [60 feet deep]. The stamp-work, at present yields about 7 per cent. * * * From every bunch of ore containing 30 tons there are taken 4 tons of what is called barrel-work, yielding 40 per cent of copper, and the addition of the masses at 60 per cent. will make the average yield of the contents entire not far from $9\frac{1}{2}$ per cent."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 132.

in masses of many hundred-weight, and at times—though less frequently,—of several tons, each. The largest bodies of metal,—which are most numerous in the south-western (lower) part of the *lode*,*—enclose, however, considerable quantities of vein-stone.

(*c.*) The *Cliff* mine *(Table XII.)*—immediately north-east of the *North American* "location,"—was, in 1845, opened beneath the precipice † of crystalline (greenstone), hornblende labradorite, and chlorite; ‡ and—having been continuously worked ever since—is now (1865) one hundred and thirty fathoms deep.§ The crystalline mass is conformably underlaid by trap-rocks; of, perhaps, much the same composition,|| but generally of granular, and frequently also of amygdaloidal,¶ structure. The varieties alternate** in somewhat ill-defined layers of unequal thickness; all,

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* "At 180 feet below the surface, a sheet of native copper, one foot in diameter, was seen to occupy the foot wall, and to extend from the bottom to the top of the gallery. The other portion of the vein, one foot in thickness, was composed of calc-spar, quartz, chlorite, and epidote, filled with small spangles of copper."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 132, *Pl. IX.*

† *Ibid*, i. *Pl. VIII.*; ii. pp. 87—8.

‡ *Ante*, pp. 398—9.

§ *Mining Journal* (2nd September, 1865), xxxv. p. 567.

|| Whitney, *Metallic Wealth of the United States*, p. 253. Rivot, *Annales des Mines*, 5me Série, vii. p. 225. *Ante*, pp. 398—402.

¶ "The zoolitic minerals, so common in the veins, and often filling the amygdaloidal cavities of the trap, do not appear to form an essential ingredient of the compact trappean rocks."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, ii. p. 90.

** "At the foot of the bluff * * * lies a fine-grained trap-rock, through which run numerous and parallel belts of amygdaloid, varying in thickness from 3 to 12 feet."—*Mining Journal* (2nd Sept., 1865), xxxv. p. 567.

however, dipping 25°—30°* N.—N.W. The imbedded minerals are, generally, either calcareous-spar, chlorite, felspar-clay, hornblendic matter, or prehnite; but neither Laumonite, zeolite, nor native copper is uncommon.†

The only *lode* yet discovered bears about 21° W. of N.—E. of S., dips 70°—85° E.,—and—varying from an inch to five feet,—averages from fifteen to eighteen inches, in width.‡

The principal earthy ingredients§ are quartz, cal-

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* Whitney, *Metallic Wealth of the United States*, p. 277. Rivot, *Annales des Mines*, 5me Série, VII. p. 312. *Mining Journal*, XXXV. p. 567. *Table XII.* column 6.

† Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 138. Rivot, *Annales des Mines*, 5me Série, VII. p. 227. *Ante*, pp. 402-3.

‡ "The lode bears north 27° east *(sic)*; underlie 10° to the east, average width 18 ins."— JACKSON, FOSTER, & HILL, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 760.

"The lode,—hardly more than an inch or two wide at the surface—is about 15 inches wide on the average; bearing north 27° west, with an underlie of 10° to the east.—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 146.

"The vein is remarkably regular in its course, which is about north 27° west, and its underlay is about 10° to the east. In the lower levels its dip is more varying, Some parts of it expand to three or four feet in width, other portions are pinched up to a few inches, but its average width is probably from 15 to 18 inches."—WHITNEY, *Metallic Wealth of the United States*, p. 277.

"Le seul filon de Cliff-Mine * * * est dirigé N. 27° O. * * * Il plonge vers l'est sous un angle de 75° à 85°; sa puissance est très-variable; elle atteint 2 mètres et même 3 mètres aux renflements et à la réunion des veines, et descend parfois à 0^{m} 25."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 311.

"The vein varies in size from 1 to 5 feet, bears a little west of north, and underlies a little east."—*Mining Journal*, XXXV. p. 567.

§ "The veinstone is composed of several gangues; drusy quartz, calc spar, chlorite, and prehnite predominate."—JACKSON, FOSTER, & HILL, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 761.

"Near the surface the gangue was mostly prehnite. * * * Further down the veinstone consisted of a series of reticulations of laumonite; [and at still

careous spar, chlorite, and prehnite; but Laumonite, zeolite, and felspar-clay are less plentiful; and epidote exists in yet smaller proportion. All these often occur intimately mixed; but sometimes particular minerals are associated with certain others only; and less frequently one or another is segregated * from the rest. Of the quartz, when thus separate, considerable portions are, at the same time, of both cellular and crystalline structure.† Masses of trap—simply granular in some, but amygdaloidal in other, places, yet always resembling the neigbouring *(Country)* rock—are frequently enveloped in the veinstone. Some of these *(Horses)* are of such dimensions that they rather split the *lode* into *branches*,‡ than form integrant parts of it; others, however, are so small, that they are thoroughly

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greater depths of] drusy quartz, calc-spar, laumonite, prehnite, and chlorite."
Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. pp. 128, 146.

The veinstone is principally quartz, calc, spar, and the zeolitic minerals, and is characterized by an abundance of finely-crystallized minerals, of which drusy quartz is the most common; it is associated with apophyllite, prehnite, and calc-spar, in various crystalline forms."
Whitney, *Metallic Wealth of the United States*, p. 277.

"La gangue est composée de quartz, chlorite, calcaire et de matière rouge, présentant toutes les variétés de disposition. * * * Les veinules de laumonite et d'épidote sont assez fréquentes, et les géodes, qui se trouvent assez souvent dans les parties puissantes du filon, sont remplies par l'argile et tapissées de trés-beaux cristaux de quartz, d'analcime, de baryte sulfatée, de prehnite et même de cuivre natif."—Rivot, *Annales des Mines*, 5me Série, vii. p. 311.

* Sedgwick, *Proceedings of the Geological Society*, i. p. 283.

† *Ante*, p. 420.

‡ Boase, *Primary Geology*, p. 179. Burr, *Mining Review*, iii. (1836) p. 227. Henwood, *Edinburgh New Phil. Journal*, xxii. pp. 156, 165; *Cornwall Geol. Trans.*, v. pp. 210—12. Fox, *Report of the Royal Cornwall Polytechnic Society*, iv. (1836) pp. 99, 124. *Ante*, pp. 20, 23, 181, 191,-3,-4, 251-9, 312,-17,-28, 381.

penetrated and pervaded* by its calcareo-siliceous constituents. The adjoining amygdaloid, on the contrary, includes nodules of many different vein-stones. Longitudinal joints occasionally divide the *lode* into *(Combs)* slices;† each of which—from some peculiarity in the nature, proportion, or disposition of its ingredients—possesses, commonly, a character of its own.

Every part of the *lode* yet seen has contained native copper;‡ mostly in *(Stamp-work*§) particles and

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* Fox, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 99. Henwood, *Cornwall Geol. Trans.* V. pp. 211—12; *Ante*, pp. 194, 250, 312, 381.

† "In the *Cliff* vein, there are two combs."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 172.

‡ "The copper occurs here, as in some other mines of this region, in masses of great size, from a few hundred pounds up to nearly one hundred tons, and the vein is not only rich in these, but also furnishes a large quantity of stamp-work, containing an unusually high percentage of copper."

WHITNEY, *Metallic Wealth of the United States*, p. 278.

§ "*Stamp-work*—which forms a large part of every vein—is prepared [for the *stamping-mill*] by being calcined and broken into small fragments. The roasting is effected in the open air. The rock is arranged in alternate layers with billets of wood, and then fired, and allowed to smoulder for forty-eight hours. Care has to be taken to distribute the heat as uniformly as possible, and not to allow any part of the copper to become fused and oxidized, as a loss would thus ensue."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 183. WHITNEY, *Metallic Wealth of the United States*, p. 261.

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 468.

"La gangue contient une forte proportion de cuivre en petits grains, et rend jusq' à 5 p. 100 de métal à la préparation méchanique."

Rivot, *Annales des Mines*, 5me Série, VII. p. 311.

Whitney, *Metallic Wealth of the United States*, p. 278.

"As the country becomes settled, and the price of labor falls, and greater method is introduced into the works, a rock containing a smaller percentage of copper may be profitably worked."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 183.

"Throughout this district the *stamp-head* is always shod, so that instead of using the *heads* until they are worn light enough to be of little service, as soon

grains, but frequently also in *(Barrel-work*)* lumps

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as the shoe is worn the *head* is taken out, and the old shoe is replaced by a new one, the whole occupying but a few minutes. The *stamps* are stopped twice a day to clean out the copper that accumulates under the *heads*. The holes in the *grates* are not less than $\frac{1}{8}$ inch in diameter. * * * The quantity [of vein-stone] stamped monthly is about 1500 tons * * * and the weight of copper extracted from it is about 30 tons. [2 per cent.] * * * The cost of crushing and treatment is only 115 cents (four shillings and nine pence half-penny) per ton of [stone] dirt."—*Mining Journal*, xxxv. p. 567.

At the *Northwest* mine, during the second quarter of 1853, 1295·52 *(Avoir.)* tons of *Stamp-work* afforded 17·72 tons (0·0136 its weight) of copper; or 30·65 lbs. per ton of *vein-stone*.

"After the mine had been laid open [by shafts, *levels*, and *winzes*] the cost, of extracting the *Stamp-work*, and of all the operations necessary for preparing the copper for the market was"

				s.	*d.*		
Extracting *(stoping)* the *vein-stone*	2 dollars		........(8	4 Stg.)		₩ ton of stone.
Raising to the surface......		26 cents	..(1	1	)	,,
Roasting (fuel, carriage and labour)		41·5 ,,	..(1	8¾	)	,,
Stamping, *dressing*, and repairs of machinery..	1 ,,	74·5 ,,	..(7	3¼	)	,,
	4 dollars	42 cents	.(18	5 ,,	)	,,

PETHERICK (WHITNEY'S), *Metallic Wealth of the United States*, p. 271.

At the *Copper Falls* mine two *stamp-heads* which weighed 2200 lbs. each, were lifted two feet, and made some seventy blows per minute, crushed in 246·9 days (1859—60) 16575 *(Avoir.)* tons of *vein-stone;* a rate which—varying from 27·01 to 36 20—averaged 33·57 tons (75188 lbs.) per *head* in twenty-four hours. The quantity of copper extracted was 17·98 tons (0·00108 its weight); or 24·3 lbs. per ton of *vein-stone*.

During the same period			*s.*	*d.*	
The exploratory works (shafts, *levels*, *winzes*. &c.)	cost on an average..	44 cents	(1	10 Stg.)	₩ ton of stone.
Extracting *(stoping)* the *vein-stone*	,,	97·5 ,,	4	0¾	,,
Raising to the surface	,,	11 ,,	0	5½	,,
Preparation for, & conveyance to, the *stamps*	,,	80·5 ,,	3	4¼	,,
Stamping, *dressing*, and repairs of machinery	,,	98 ,,	4	1	,,
Carriage to the wharf, shipping-charges, &c.	,,	7·5 ,,	0	3¾	,,
Agencies, & incidental expenses.	,,	25·5 ,,	1	0¾	,,
		3 dollars 64 cents	(15	2)	,,

WILLIAM PETHERICK, ESQ., Superintendent of the Mines, MSS.

* "The pieces which are raised to 30 per cent. of metal by beating off the rock

of several pounds, and at times in *(Masses*)* bodies

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are packed in barrels, and called *Barrel-work*."—JACKSON, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 468.

"*Barrel-work* is the name given to the smaller masses of copper, which are too large to go under the *stamps*, and too small to be shipped separately. It includes masses of copper in bunches and string-like forms, which are firmly bound together with a greater or less amount of the veinstone, and weighing from a few pounds up to several hundred. These smaller masses are dressed by the hammer, to free them as much as possible from the adhering rock, and barrelled up in stout casks which hold from five to eight hundred pounds of metal and rock. * * * The *barrel-work* at the *Cliff* mine is estimated at 50 per cent. of pure copper.— FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 182.

Whitney, *Metallic Wealth of the United States*, p. 261. Rivot, *Annales des Mines*, 5me Série, VII. p. 288.

* "When a large sheet of copper occurs in the vein, the rock is removed from one side of it, and it is thrown down by means of a *sand-blast*.[a] Masses have been detached from the vein which were estimated to weigh 60 or 70 tons, mostly of solid copper, in an irregular, flattened, tabular shape, now expanding to a width of from 2 to 3 feet, and then contracting to a few inches, but firmly united. Of course * * * it is important that as little of the process of subdivision as possible should be done underground, since the operation impedes the work of the mine and is less conveniently executed in a confined space * * * where the mass cannot be readily moved. * * * The process of dividing the masses, at present is as follows, and is the same whether above and below the surface. A groove is cut diagonally through the mass, at a convenient point, where the copper is very pure and the thickness comparatively small. To effect this, one person guides a chisel about three-quarters of an inch in width,[b] and another strikes it with a heavy sledge, * * * until at last a chip [c] of copper is taken out several inches in length. * * * If the copper be perfectly pure, the operation proceeds rapidly; but when quartzose matter intervenes, the labor is more tedious. * * * When the masses have been brought to the surface, they are still further subdivided, if necessary, into pieces varying from one to two tons—such may be conveniently transported to the lake, whence they are shipped to market."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 182.

"L'abatage des grandes masses est assez complexe: on commence par le dé-

a "A small drift is driven for a few fathoms behind the vein, and several—in some cases fifty—25 lb. kegs of powder are put in, closely covered with fine dirt, and fired; this is termed *Sand-blasting*."—*Mining Journal*, XXXV. p. 567.

b "The chisels are about ¾ of an inch in width."

WHITNEY, *Metallic Wealth of the United States*, p. 260.

"Les rainures ont 2 centimètres (0·78 inch) de large."

RIVOT, *Annales des Mines*, 5me Série, VII. p. 285.

c "Copper chips crumple to about two-thirds the [length of] the surface from which they are cut. At the *Cliff* mine a copper chip some thirty inches in length was cut from a mass which had been brought to the surface."—*Lake Superior Miner*, II. (1st August, 1857) p. 2.

of many tons each. Some of the largest consist, here and there, of parallel sheets; varying—from a fraction

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gager au toit et au mur, en ne laissant de ce côté qu'un vide peu large du côté du mur. Si les dimensions en hauteur ne sont pas trop grandes, on fait tomber la masse d'un seul morceau sur le niveau inférieur au moyen de barils de poudre placés derrière. Si au contraire la masse de cuivre s'étend d'un niveau à l'autre, on la divise au ciseau en grands morceaux qu'on puisse détacher d'une pièce, et en choisissant pour les lines de division les points les moins épais. On fait ensuite tomber à la poudre les morceaux coupés successivement, en commençant par la partie supérieure. Une fois la masse ou ses grands morceaux abattus sur le sol d'un niveau, on les coupe en fragments dont le poids varie de 1 à 2 tonnes: la section est faite au ciseau, en pratiquant des rainures par l'enlèvement de copeaux. On place les fragments sur des chariots, et on roule sur chemins de fer jusqu'au puits spécial destiné à l'enlèvement des masses, et muni d'un cabestan à deux ou quatre chevaux."

Rivot, *Annales des Mines*, 5me Série, VII. pp. 284—5.

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 435. Whitney, *Metallic Wealth of the United States*, pp. 260–1. *Mining Journal*, XXXV. p. 567.

"At this time [1849] the miners receive 10 dollars (£2 : 1 : 8 Stg.) per square foot of cut surface, measuring on one side of the cut, for dividing the large masses of copper into pieces capable of being transported."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 435.

"The Superintendent of the *Copper Falls* mine states that there being no rock in a mass of copper which weighed seven tons, he was enabled to cut it up by means of a *cross-cut* saw, at a cost of only 6 dollars (£1 : 5 : 0) per square foot of cut surface."—*Ibid*, p. 437.

"The cost of cutting is from six to seven dollars (£1 : 5 : 0 to £1 : 9 : 2 Stg.) per square foot of surface cut through.—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. (1850) p. 181. Whitney, *Metallic Wealth of the United States* (1854) p. 261.

"Le travail est très-long et coûte fort cher, de 45 à 75 fr. (£1 : 16 : 0 to £3 Stg.) par pied quarré de surface coupée."

Rivot, *Annales des Mines*, 5me Série, VII. (1855) p. 285.

"Copper cutters are paid fifteen dollars (£3 : 2 : 6 Stg.) per superficial foot."

Mining Journal, XXXV. (1865) p. 567.

"The prices now (1865) paid for cutting copper, are

at the *Minesota* and *National* mines	.... ten dollars	(£2 : 1 : 8)	℔ square foot;
" *Cliff*	" .... twelve	" (£2 : 10 : 0)	"	;
" *Flint Steel*, where the metal is harder	.. fourteen	" (£2 : 18 : 4)	"	.

"Three men take ten hours to cut a groove nine inches long and nine inches deep with a three-quarter inch chisel."

Captain J. T. Brown, Manager of the *Ontonagon* Copper Mine, MSS.

of an inch to several inches—in thickness, and—from a few feet to many fathoms—in length and depth. In various parts of their range, however, the selfsame *sheets*,—are separated by thin slices *(Horses)* of the different vein-stones,—touch, but slightly cohere,—and unite to form masses of considerable thickness. These are mostly of either fibrous or granular structure; *

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* It was ascertained by Dr. Jackson that the specific gravity

of a *chip*, supposed to have been condensed in process of being cut, from one of the largest masses found at a depth of 40 fms. in the *Cliff* mine,	was	8·8900
of a crystal from the *Cliff* mine	„	8·9300
of a slice from a large mass at the *Copper Falls* mine	„	8·9308
	Mean....	8·9169

Report on the Geological and Mineralogical Survey of Lands in Michigan, III. pp. 474—6.

(*a*.) Ordinary smelted copper, examined at different stages in the process of *(poling)* refining, varied in specific gravity from 8·2980 to 8·6540.

Napier, *London, Edinburgh, and Dublin Phil. Mag.* 4th Series (1853), v. pp. 489—90.

(*a*—1.) "The specific gravity of electrotype copper, melted under charcoal and treated in various ways, is shown in the following table;—

Cast under ordinary circumstances, and therefore vesicular	.. from	8·5050 to 8·5350
„ in a mould containing charcoal enough to cover the surface and exclude all action of the air	.. „	8·9220 „ 8·9520
Poured through a current of coal-gas which entered and filled a covered mould	.. „	8·9480 „ 8·9580

Dick, *London, Edinburgh, and Dublin Phil. Mag.*, 4th Series, (1856) xi. pp. 424—5. Percy, *Metallurgy*, i. p. 286.

"The difference occasioned by pouring the metal through an oxidizing medium like atmospheric air, or a reducing one like coal gas, was observed many times; and it was found easy * * * to cast from the same crucible one ingot of copper which should be porous and, immediately afterwards, another which should be perfectly free from porosity. * * * .

"Steam * * * exerts neither an oxidizing nor a reducing action."

Dick, *London, Edinburgh, and Dublin Phil. Mag.*, 4th Series, xi. p. 423. Percy, *Metallurgy*, i. pp. 267, 277.

(*a*—2.) Copper precipitated from a solution of the sulphate of copper (cement-copper) and melted under common salt, varied in a specific gravity from 8·8850 to 8·9070. Specimens subjected to the pressure of suitable apparatus underwent the following changes;—

but some of the largest and richest contain *(vughs)*

Specific gravity before compression.	Pressure. lbs. *(Avoir.)* per square inch.	Specific gravity after compression.	Ratio. Uncompressed metal = 1·
8·8910	100·13	8·9220	1·003487
8·8990	,,	8·9190	1·002247
8·8850	150·20	8·9280	1·004840
8·9070	300·40	8·9310	1·002695

Marchand & Scheerer—Percy, *Metallurgy*, i. pp. 284—5 (abridged).

(*b.*) "The following are the appearances which copper in different stages of *poling* has under the microscope ;—

1st. Ready for *poling*. Red-brown colour, vitrified, sandy fracture. Sp. gr. 8·491.

2nd. Slightly *poled*. Colour redder than the last, sandy fracture, a less vitreous appearance. Sp. gr. 8·526.

3rd. Colour lighter with more lustre, fracture hard, not sandy but vitreous. Sp. gr. 8·481.

4th. Longer *poled*. Colour brighter, with more metallic lustre, less vitreous, and having minute cavities. Sp. gr. 8·397.

5th. Near to *tough pitch*. Colour still brighter, fracture full of minute cavities as if the metal had *set* whilst gas was escaping, slightly vitreous. Sp. gr. 8·582.

6th. *Tough pitch*. Colour very bright, lustre metallic, the cavities seemed collapsed, giving a fracture resembling a honey-comb, strongly compressed. Sp. gr. 8·654.

7th. A little *overpoled*. The collapsed cells extended; some of the cavities oval, as if a gas had escaped. Sp. gr. 8·594.

8th. Further *overpoled*. Full of cavities, fracture crystalline and vitreous. Sp. gr. 8·518.

9th. Much *overpoled*. Very hard and vitreous, fracture like a crystalline network. Sp. gr. 8·298.

"These appearances seem to indicate the changes going on within the metal during *poling*, and the specific gravity of each corresponds with its appearance."

Napier, *London, Edinburgh, and Dublin Phil. Mag.*, 4th Series, v. pp. 489—90 (abridged).

"When copper at *tough pitch* is cast into a narrow open ingot mould * * * and the ingot is broken in two cold, its fractured surface is even, close-grained, free from fibres or cavities, presenting, especially towards the centre, numerous shining grains of bright metallic lustre."—Percy, *Metallurgy*, i. p. 266.

"When *tough pitch* copper is kept melted under charcoal during a sufficient time, and is then laded into a narrow open mould * * * it is more or less brittle, so that the ingot may be easily broken. Its fractured surface is more uneven than that of *tough pitch* copper, and it appears fibrous throughout."

Ibid, p. 268.

"Copper from different works may differ a little in the diameter of the cells, and consequently in the number contained, but the general range seems to be

cavities, lined with crystalline facets, more frequently than with perfect crystals, of copper; encrusted, now and then, with quartz, calcareous-spar, and other earthy substances.* Such portions of the vein-stones as adjoin,

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from 500 to 1000 in the linear inch. * * * The partitions between the cells are so thin that there seem to be openings from each one to its surrounding cells; so that—as in silver—there is an internal communication throughout the entire mass."—VIVIAN, *Report of the British Association* (1861), Part II. p. 35.

"When melted copper is oxidized by exposure to the air, * * * the oxide formed is dissolved in the metal."

NAPIER, *London, Edinburgh, and Dublin Phil. Mag.*, 4th Series, v. p. 287.

"Copper in a state of fusion has the property of dissolving dioxide of copper to a considerable extent. When it contains this oxide to the maximum, it is technically called *dry copper*. * * * An ingot of copper in its *driest* state * * * contained from 9·34 to 10·21 per cent. of dioxide."

PERCY, *Metallurgy*, I. pp. 264—5.

"The highest amount of dioxide detected [in *tough pitch* copper] was 2·95 per cent."—*Ibid*, p. 266.

(*b*—1.) "Electro-deposited copper shows, under the microscope, no trace of vesicular structure."—JAMES NAPIER, ESQ., of Glasgow, MSS.

"The copper precipitated from mineral water, on scraps of wrought iron and shreds of tin-plate, near the mouth of the Gwennap Adit in Cornwall (*Corn. Geol. Trans.* v. pp. 89*, 422—3), at the *Parys* and *Mona* mines in Anglesea (*Annales des Mines*, XIII. (1826) pp. 229—35), and at *Cronebane*, *Ballygahan*, *Ballymurtagh*, and *Connorree* in Wicklow (*Records of the School of Mines*, I. p. 378), as well as the native copper of this country, of South America, and of Cuba, is slightly mixed with particles of ruby-copper, and mostly crystalline; but of vesicular structure it shows no trace.

"The native copper of Lake Superior is sometimes thinly invested with ruby-copper, at the surface; but never at greater depths. The extremities of the larger masses are here and there crystalline; but their internal structure is always granular or fibrous."

WILLIAM VIVIAN, ESQ., Manager of the *Parys* Mine, MSS.

The foregoing comparisons are—in a theoretical point of view—highly suggestive.

According to M. Gustavus Rose, molten gold is of higher specific gravity than native gold.—*Annales des Mines*, 3me Série, v. p. 168. *Ante*, p. 335, Note ||.

* "At the Cliff and North American mines perfect crystals of copper occur only in the cavities of the matrix."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 173.

"The finest crystals which we have obtained were from the Cliff mine, where they are frequently thrown out with the gangue, which is generally, where the

and are encompassed by, these ample sheets and heavy masses, are interlaced with filaments, threads, and—so to speak—thick, crooked, gnarled branches, often studded with granules, scales, and crystals,* of native copper. But much as various parts of the earthy matrix may differ in composition, as long as they maintain an uniformly compact structure, the threads of metal with which they are reticulated preserve the same character. In regularly crystallized vein-stones, however, the copper mostly follows the faces of crystallization; † though sometimes it ramifies

copper occurs crystallized, drusy quartz associated with calcareous spar. These crystals are generally tetrahexahedra; the largest which we have is one-fourth of an inch in diameter, * * * The crystals, however, are rarely perfect, being almost always much distorted; and, often, only one or two crystalline planes are to be recognized on the extremity of a shapeless, elongated mass. We have seen, from the Cliff and Copper Falls mines, octohedral crystals, some of which were nearly an inch in diameter; cubical crystals also occur at the last named locality."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, II. p. 99.

"Les grandes masses de cuivre contiennent des noyaux de toutes dimensions, de la gangue des filons, du calcaire spathique mélangé avec du quartz, du feld-spath, et des fragments de trapp non altéré."

Rivot, *Annales des Mines*, 5me Série, VII. p. 260.

* "But few good crystals have come into our possession, as they are highly valued by those interested in the mines, and of course difficult to be obtained."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, II. p. 99.

€ The miner—as well abroad as at home—considers every rare and beautiful mineral he may discover as his own peculiar privilege; and accordingly appropriates it at once. Crystals of native copper, and specimens of virgin silver are, therefore, unobtainable at the mines or in the neighbouring villages; but in the collections of most English mineral-dealers, both are abundant.

† "We find copper deposited in thin plates between the joints of crystallized quartz."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 173.

"A compound group of twin-crystals [of copper] lay within a crystal of transparent calc-spar; the individuals of which had assumed, in reference to the main stem, the angle of the rhombohedral crystal in which they were enclosed."

Ibid, II. p. 99.

through,* and occasionally it envelopes,† perfect crystals of various earthy minerals. *Slickensides*—sometimes simply polished, but more frequently grooved with either straight and parallel, or curved, crooked, and divergent striæ,‡—are numerous in both the stony and the metallic ingredients. But on opposite sides of a longitudinal joint in the *lode*, both the character of the matrix and the disposition of the metal are often materially different; the lower, or western, portion containing the *(Masses)* largest bodies, the upper, or eastern, small *nuggets*, and particles *(Barrel and Stamp-work)* only; § yet *Masses* occupy the entire

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"At the Cliff mine native copper was found impressed with crystals of prehnite, of calc spar, and of quartz."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 407.

* "We find small specks of copper enclosed in obtuse rhomboidal crystals of calc-spar, variously modified."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 173.

"Crystals of analcime occur * * * completely filled, throughout their whole interior, with delicate ramifications of metallic copper, so that, if the silicious material were dissolved out, the form of the crystal would still be recognized by the mass of metallic matter remaining."—*Ibid*, II. p. 99.

† "At the Copper Falls mine * * * we find native copper deposited *around* crystals of analcime and calc-spar, taking the form of the faces of the crystals, every line and wave being faithfully represented, as in the electrotype process."

Ibid, I. p. 173.

‡ Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 168. Whitney, *Metallic Wealth of the United States*, p. 260.

Henwood, *Edinburgh New Phil. Journal*, XXII. p. 161; *Cornwall Geol. Trans.*, V. pp. 53, 172,—81; *Ante*, p. 13, *Fig.* 2.

§ "In the Cliff mine, there are two combs—that attached to the foot wall containing most of the masses, while the other carries disseminated copper."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 172.

"The sheets of native copper, as a general thing, though not invariably, occupy the foot-wall of the vein."—*Ibid*, p. 172.

width * in some, whilst *Stamp-work* occurs alone in other, places.

From 1848 to 1852 the different qualities of *vein-stuff* were obtained in the following quantities and proportions ;†—

	Weights. tons. (*Av.*)	Proportions.
Masses, estimated to contain 60 per cent. of copper,	2,103·54 ..	0·139
Barrel-work, „ 50 „ „	1,230·35 ..	0·081
Stamp-work, „ 5 „ „	11,823·15 ..	0·780
Total	15,157·04 ..	1·

According to these estimates, the quantities and pro-

"Les petites masses sont dans la matière argileuse rouge; les grandes sont souvent entourées de calcaire spathique."

Rivot, *Annales des Mines*, 5me Série, VII. p. 260.

* "Sheet copper often occupies the entire vein."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 146.

"The greatest thickness of a solid mass of copper, without seam or break, observed by us was two feet four inches. This was at the Cliff mine."

Ibid, p. 182.

"J'ai vu dans la mine des masses de plus de 2 mètres (6 feet 6¾ inches) d'épaisseur."—Rivot, *Annales des Mines*, 5me Série, VII. p. 311.

† "The relative amount of the various kinds of mineral raised from the mine, for five years in succession, may be seen in the following table :—

Years.	*Masses*, estimated to contain 60 per cent of copper. Tons (*Av.*)	*Barrel-work*, estimated to contain 50 per cent. of copper. Tons (*Av.*)	*Stamp-work*, estimated to contain 5 per cent. of copper. Tons (*Av.*)	Totals. Tons (*Av.*)
1848	540·11	217·18	1,731·87	2,489·16
1849	481·29	252·81	2,493·08	3,227·09
1850	316·98	215·32	2,743·30	3,275·60
1851	373·39	230·12	2,729·46	3,332·97
1852	391·86	314·22	2,125·44	2,832·22
Totals	2,103·54	1,230·35	11,823,15	15,157·04
Proportions..	0·139	0·081	0·780	1·

Whitney, *Metallic Wealth of the United States*, p. 278 (Enlarged).

As the navigation of Lake Superior is periodically interrupted by ice, the produce of the mines during winter, does not reach the market until the following summer. (*Postea*, p. 440.)

portions of fine copper were—

in the *Masses*	1,262·12	tons (*Av.*)..	0·511
„ *Barrel-work.*	615·17	„ ..	0·249
„ *Stamp-work.*	591·16	„ ..	0·240
Total	2,468·45	„ ..	1.

The *vein-stuff* extracted contained, therefore, on an average, about 0·163 its weight of copper.

Some 8,270 square fathoms of the *lode* *—obtained, from 1845 to 1853, between the surface and a depth of (83·3 fathoms) 500 feet—afforded

11,785,515 lbs.† (5,261·38 tons *Av.*) of crude metal; or, on an average, 1,425 lbs. of fine copper per square fathom;

which yielded

6,208,678 lbs.† (2,771·73 tons *Av.*) of fine copper; or „ , 751 lbs. „ .

As, however, the *lode* averaged no more than from fifteen to eighteen inches in width; ‡ the portion wrought measured—

cubic fms.		lbs.		lbs.
from 1,722·92,	which contained	from 6,840 of crude metal,	and this yielded	from 3,6Q5 of fine copper,
to 2,367·50,	„	to 5,700 „ ,	„	to 3,004 „ ,

per fathom.

* "The remarkable and uniform richness of the vein may be inferred from the fact, that no part of it is so poor as not to be worth taking down, and so far as the work has been carried, hardly a fathom of ground has been left standing in it. On calculating the number of fathoms of the vein removed in the drifts, shafts, and stopes, I find it to be, approximately, 8,270; and there has been produced an average amount of 761 pounds of copper per fathom, a result which is truly astonishing, when it is considered that the *whole* of the vein has been taken down."—Whitney, *Metallic Wealth of the United States*, p. 277.

"On estime que dans toute la partie exploitée, chaque mètre carré (10·76 square feet) de surface latérale a rendu plus de 100 kilogrammes (220 lbs. *Av.*) de cuivre pur."—Rivot, *Annales des Mines*, 5me Série, VII. p. 313.

† *Ibid*, p. 278. S. T. Snow, Esq., of the *Revere Copper Works*, Boston, MSS.

‡ Rivot, *Annales des Mines*, 5me Série, VII. p. 277. *Ante*, p. 423.

tons. (*Av.*)				fms.		tons		
5,261·38	of crude metal otained between	the surface	and a depth of	83·3,	afforded	2,771·73,	or 0·5268	its weight of fine copper;*
whilst								
14,091·09	„	83·3	and	130·0,	„	9,231·15,	„ 0·6551	„ ;†
and								
19,352·47	„	the surface	and	130·0,	„	12,034·81,	„ 0·6219	„ .

The average proportions of fine copper contained in crude metal from the different depths,‡ therefore, are—

between the surface and a depth of	83·3 fms.	1·
„ 83·3 and	130·0 „	1·2435.

Particles, grains, and small masses of virgin-silver frequently bestud, and are imbedded in, native copper, as well as in prehnite and calcareous spar; the silver, however, is more plentiful in a metallic than in an earthy matrix, and in the shallower than in the deeper parts of the *lode*; yet, ultimately mixed and closely united as the metals often are, they never form an alloy.§

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* *Postea*, p. 440.

"Près de la surface, les masses de cuivre ont été plus nombreuses; aux cinquiéme et sixième niveaux, les mosses sont plus fortes et la proportion de matière à bocarder semble augmenter assez rapidement."

Rivot, *Annales des Mines*, 5me Série, vii. p. 313.

† Small quantities of crude metal were, of course, still obtained from the upper *levels*.

‡ *Ante*, pp. 120—1, 179, 205—6, 285—6, 328—31, 383.

§ "Native silver, more or less associated with the copper, is most abundant near the cross-course."—Jackson, Foster, & Hill, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, iii. p. 760.

"Two specimens [specific gravity 10·146 and 10·188 respectively] were found to contain small particles of copper scattered through them, but the copper was not alloyed with the silver. These specimens were found mixed with the veinstone, associated with native copper. They were in grains from the size of a mustard-seed to pieces of more than an ounce in weight. * * * The singular fact of the occurrence of silver implanted in masses of solid copper, or dotting its surface like buttons dropped upon the copper and united by a metallic soldering or perfect metallic adhesion at the points of contact is observed in this mine, as also at the Copper Falls, Lake Superior, North American, and Northwest Companies' mines. I have analysed hundreds of specimens without finding any true alloy of the copper and silver."—Jackson, *Ibid*, iii. p. 476.

Wherever the adjoining rocks are of amygdaloidal

"In a sample of the veinstone blasted from the Cliff mine * * * the silver amounted to 663·64 grains per ton [0·000042 the weight] of rock."

"Native silver occurs by no means unfrequently, at various points of the trap range, from one extremity of the district to the other. It has, however, been found in the greatest quantity at the Phœnix (formerly Lake Superior), Cliff, Copper Falls, and Minnesota mines, * * * but is most abundant near the junction of [different rocks]. * * * The silver is often interspersed in the mass of copper, so as to form a species of porphyry, the former metal occurring in small patches and particles perfectly soldered to the enclosing mass of copper, yet, chemically speaking, entirely distinct from it. The native silver seems to occur specially in connexion with a soft greenish magnesian mineral, also with calc-spar and prehnite, and has never, so far as we know, been found distinctly crystallized, as the copper often is."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. pp. 146, 178.

"The largest mass of silver obtained up to this time weighed more than six pounds."—*Ibid*, II. p. 108.

"The amount of silver obtained from the Cliff mine has sometimes been quite considerable. Early in the history of its operations, a great excitement was raised on the subject * * * a rich pocket of it having been met with; but experience has uniformly shown that in the Lake Superior veins these bunches of silver are of limited extent. * * * The mode of occurrence of the silver is precisely similar to that of the copper; like that metal it is found only in the native state. * * * The argentiferous portion of the lodes seems to be, in general, near the plane of contact of two beds of different lithological character.

"The silver rarely forms lumps of more than a few ounces in weight, although some pieces weighing several pounds, and nearly pure, have been obtained. Unfortunately such pieces are often looked upon by the miners as their especial property, and the amount received by the companies from this source is considerably less than it ought to be.

"The annexed is a statement of the amount of silver obtained at the Cliff mine; it is mostly picked out by hand from the coarse metal which is taken out from under the stamp-heads.

1846	25·16 lbs. Troy.	1849	24·75 lbs. Troy.
1847	32·50 „ .	1850	23·90 „ .
1848	81·25 „ .	1851	34·83 „ .

$$\underbrace{\hspace{20em}}_{\text{Total .... 221·39 lbs. Troy."}}$$

Whitney, *Metallic Wealth of the United States*, pp. 278—9.

"L'argent natif est assez abondant vers la surface, mais presque toujours assez intimement mélangé avec le cuivre; on n'a pas encore constaté dans quelles parties du filon l'argent est plus ordinairement en forte preportion; il est dans les veines de calcaire spathique, mélangé de feldspath et de quartz, qui semblent répondre à la séparation des bancs de trapp de texture différente, mais cette loi est bien loin d'être certaine. * * * La mine n'a pas livré plus de

structure the *lode* contains copper;* but in the hard and crystalline, as well as in the soft and porous, beds, it is frequently made up of several narrow veins, and these are seldom rich.†

The more or less metalliferous vein-stones form *shoots*, ribands, or stripes of various qualities; which —declining from the far distant‡ granite,§ but co-inciding in position with the contiguous bands of more or less congenial amygdaloid—have, within the *lode*,

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110 kilogrammes (294·74 lbs. Troy) d'argent en six ans de 1846 à 1851, et on ne peut pas espérer un meilleur résultat pour l'avenir."

Rivot, *Annàles des Mines*, 5me Série, vii. pp. 311, 314.

Daniel, *Mining Journal*, xxxv. p, 567. *Ante*, p. 419.

* "The most favorable rock—that in which a vein is best developed—is a granular trap, with occasional amygdules scattered through it of a lively color, and possessing a good degree of firmness."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 170.

"The true copper-bearing rock is * * * of a fine texture, not too crystalline, and with occasional amygdules scattered through it."

Whitney, *Metallic Wealth of the United States*, p. 258.

Ante, p. 402, Note.

† "Where the vein exists in the greenstone or hard crystalline rock it is pinched; where it enters the soft porous amygdaloid, it becomes scattered and ill-defined.—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 170.

"Dans le greenstone on ne distingue plus de veines principales, les filons se divisent en un grand nombre de veinules."

Rivot, *Annales des Mines*, 5me Série, vii. p. 251.

"Whether the rocks be granite, slate, or *elvan*, their hardest portions are always quartzose, and in these the *lodes* are seldom rich; * * *

"Where both the rocks and *lodes* are very soft, the *lodes* are usually large; and under such circumstances they almost always split into strings, which commonly consist of iron-pyrites and frequently die away in the *Country*."

Henwood, *Cornwall Geol. Trans.*, v. pp. 220, 231.

‡ *Geological Map of the Lake Superior Land District*, by J. W. Foster and J. D. Whitney. Rivot, *Annales des Mines*, 5me Série, vii. Pl. VII.

§ Henwood, *Edinburgh New Phil. Journal*, xxii. p. 157; *Cornwall Geol. Trans.* v. pp. 41, 54, 87*, 129, 193.

an endlong dip,* of about 28° towards the north.†

The crystalline greenstone of the precipice is separated from the granular and amygdaloidal trap-rocks beneath by a conformable bed‡ (the *Slide*) of chloritic conglomerate, from three to about twelve feet in thickness,—which *heaves* the *lode* about two fathoms (L.—S.A.) towards the *left-hand*.§

Although the works are but one hundred and thirty fathoms deep, a man-engine || has been already erected.

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* Henwood, *Edinburgh New Phil. Journal*, XXII. p. 157; *Cornwall Geol. Trans.* V. pp. 41, 54, 87*, 129,—93;—VI. pp. 146,—94. Tregaskis, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 96. *Ante*, pp. 122, 206—7,—15,—16, 224,—34,—58, 323,—6.

† "The mining ground * * * [dips towards the north] below the cliff of greenstone, in a belt of amygdaloidal trap."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 129.

"The beds of rock dip at an angle of about 28° to the north, consequently the extent of ground in that direction * * * is increasing as each successive level extended northward from a greater depth."

Whitney, *Metallic Wealth of the United States*, p. 277.

"A Cliff et à South-Cliff, les masses sont abondantes et de très-grandes dimensions à une faible distance de la surface; elles se continuent dans la profondeur, en formant des colonnes inclinées irrégulièrement vers le nord, à peu prés comme les bancs du trapp; la gangue du filon est imprégnée de cuivre et fournit du minerai de bocard assez riche."–Rivot, *Annales des Mines*, 5me Sér., VII. p. 261.

‡ "Between the crystalline greenstone and the—occasionally amygdaloidal—granular trap there is a thin belt of slaty chlorite about twelve feet in thickness. * * * In the granular trap the vein is about twelve feet to the east [of its place in the greenstone] showing that it had been subjected to that amount of heave or dislocation."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. pp. 127—8 (Abridged).

"At the foot of the Cliff, and separated from it by a slide—the slide of the district—lies a fine-grained trap-rock, through which run numerous and parallel belts of amygdaloid. This, with the amygdaloid and slide, dips north under the greenstone at an angle of about 28°. * * * The copper-ground is about 1,000 feet in length, being limited north by the slide, and dipping at the same angle with it under the greenstone."—Daniel, *Mining Journal*, XXXV. p. 567.

§ *Table XII.*

|| "A man-engine works in Avery's shaft, raising the men from, and lowering them to the 100 fathom level; it is contemplated to carry the rods to the 130, when the shaft is sunk to that depth."—Daniel, *Mining Journal*, XXXV. p. 56.

From 1844 to 1865 the Pittsburgh and Boston Mining Company obtained
20,359·56 tons of crude metal,* containing (0·6227 its weight)
12,679·37 „ of fine copper, which realized £1,443,039
The expenditure, meanwhile, amounted to 963,179

A net profit of £479,860

* The produce of the mine and the financial operations of the Company, from 1844 to 1865, are shown in the following columns :—

Years.	Crude metal. Tons (*Av.*)	Proportion of fine copper in crude metal.	Fine copper. Tons (*Av.*)	Proceeds of copper.	Expenditure	Loss	Profit.
1844	—	—	—	—	£ 639	£ 639	—
5	14·81	0·6000	8·88	£ 618	5328	4710	—
6	48·56	0·3458	16·80	1848	13776	11928	—
7	325·82	0·5629	183·38	14786	18626	3840	—
8	738·97	0·6020	444·85	34668	21933	—	£ 12735
9	1020·11	0·5611	572·38	32339	22285	—	10054
1850	679·19	0·4697	319·04	36884	24747	—	12137
1	682·35	0·5538	377·90	36444	26588	—	9856
2	741·22	0·4995	370·25	33733	23527	—	10206
3	1010·35	0·4733	478·25	60968	38669	—	22299
4	1041·35	0·5639	587·19	66830	44501	—	22329
5	1337·43	0·6249	836·70	99148	53941	—	45207
6	1469·30	0·6748	991·49	111634	59687	—	51947
7	1501·59	0·7028	1055·29 31·93*a*	103723	66415	—	37308
8	1421·02	0 7101	1009·12	100432	59843	—	40589
9	981·98	0·6433	631·70	60938	56703	—	4235
1860	1252·43	0·6571	822·94	72978	57561	—	15417
1	1385·55	0·6212	860·72	85102	70650	—	14452
2	1411·81	0·6340	895·07	108320	67355	—	40965
3	1343·99	0·6977	937·66	149818	61226	—	88592
4	944·64	0·6386	603·27	131251	85181	—	46070
5	1007·09	0·6400	644·56	100577*b*	83998*b*	—	16579
Totals.	20,359·56	—	12,679·37	£1,443,039	£963·179*c*	£21,117	£500,977
Mean		0·6227				Loss........	21,117
						Net Profit ..	£479,860

a "Recovered at this time from the Slags of former years." *b* Estimates.

c "By the terms of the [earlier] leases the applicant was required to * * * render to the United States six per cent. of all the ores raised."—Whitney, *Metallic Wealth of the United States*, p. 248.—"In 1853, however, the *General Law of Michigan* imposed a tax of one dollar (four shillings and two pence Stg.) on each ton (2,000 lbs. *Av.*) of copper or mineral obtained * * * in lieu of all State taxes."

The accounts of the first nine years have been compiled from the statements of Mr. Whitney (*Metallic Wealth of the United States*, p. 278,) and M. Rivot (*Annales des Mines*, 5me Série, vii. p. 313); but those of the twelve last have been prepared from particulars courteously supplied by T. M. Howe, Esq , Treasurer and Secretary of the Pittsburg and Boston Mining Company, and S. T. Snow, Esq., of the Revere Copper Company, on application from the Author's friends, Ebenezer North Willcox, Esq., of White Woods, near Detroit, and Joseph P. Cooke, Jun., Esq., Professor of Chemistry and Mineralogy in the University of Cambridge, Massachusetts

therefore accrued to the fortunate shareholders.

A comparison with these results with those obtained in other rich mines may not be deemed impertinent.

The *Consolidated Copper Mines*, of *Cobre*, near Santiago de Cuba, have been worked in "highly calcareous porphyritic rocks, passing into and associated with basalts and a peculiar conglomerate" (ANSTED, *Quar. Journal of the Geological Society*, XII. p. 145), with unequalled success; of which the following particulars have been—by permission of the Directors, copied from official records.

Years.	Copper-ore. Tons (*Av.*)	Proceeds.	Expenditure.	Loss.	Profit.
1835	3478	£ 63634	£ 40464	—	£ 23170
6	4765	80442	85709	£ 5267	—
7	6084	100221	96846	—	3375
8	10519	199429	117702	—	81727
9	13615	203028	166167	—	36861
1840	23279	344479	221520	—	122959
1	24658	329030	256800	—	72230
2	20145	234596	223103	—	11493
3	20255	242217	212806	—	29411
4	22526	238821	223776	—	15045
5	17469	193417	183092	—	10325
6	15291	163270	161234	—	2036
7	16593	191644	168632	—	23012
8	21762	217958	171847	—	46111
9	19773	243291	159900	—	83391
1850	17903	229144	150504	—	78640
1	15605	217937	134677	—	83260
2	11078	187781	111444	—	76337
3	13090	214003	150083	—	63920
4	16530	255668	150644	—	105024
5	17531	271588	172784	—	98804
6	14617	217031	178713	—	38318
7	13325	184151	149122	—	35029
8	13008	162045	135954	—	26091
9	13812	191796	141032	—	50764
1860	13602	183463	145784	—	37679
1	13249	157037	145524	—	11513
2	11796	131519	141977	10458	—
3	14955	144728	140911	—	3817
4	13248	148261	135114	—	13147
Totals....	453,561	£5,941,629	£4,673,865	£15,725	£1,283,489

Each ton of ore, therefore, cost on an average	£10 : 6 : 1	Loss	15,725
,, ,, was sold for	14 : 0 : 0	Net profit ..	£1,267,764

For this interesting document the Author is indebted to his friend FREDERICK BANKART, ESQ., of the *Red Jacket Copper Works*, near Briton Ferry.

Each ton of fine copper therefore cost............	£ 75	19	3	Stg.
and was sold for	113	16	3	,,

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The *Knockmahon Mines*, between Dungarvan and Tramore, in the county of Waterford, are largely wrought by the Mining Company of Ireland, in the slate-series, near the coast, and, to some extent, beneath the sea (Weaver, *Geol. Trans.*, o.s., v. p. 248. Oldham, *Reports of the British Association* for 1844, p. 221.)

"From the beginning of 1825 to the end of 1865

The Copper-ores obtained were sold in Swansea for		£1,399,232
,, Salaries, wages, materials, &c., amounted to	£855621	
,, Royalties (Dues)............ ,, ...	54458	
,, Profits .... ,, ...	489153	
		£1,399,232

Robert Heron, Esq., Secretary of the Company, MSS.

The following particulars relate to mines in various parts of Cornwall and Devon.

The Saint Just District. (Borlase, *Natural History of Cornwall*, pp. 101, —52,—56,—62, 206,—9. Pryce, *Mineralogia Cornubiensis*, p. 21. Berger, *Geol. Trans.*, o.s., i. pp. 151,-76. Davy, *Cornwall Geol. Trans.*, i. pp. 20—6. De Luc, *Geological Travels*, iii., pp. 257,-60. Rashleigh, *British Minerals*, i. pp. 31—3. Polwhele, *History of Cornwall*, ii. pp. 133—5. Lysons, *Cornwall*, p. ccvi. Hawkins, *Cornwall Geol. Trans.*, ii. pp. 29—30. Carne, *Ibid*, ii. pp. 87—8, 103,-10,—21,-2, 290-358; *Pl III. Fig.* 10;—*VII.; Ibid*, vi. pp. 28—9, 47—9. Forbes, *Ibid*, ii. pp. 175—81, 249,—55—8, *Pl. VI.* T. F. Barham, *Ibid*, iii. p. 151. Michell, *Manual of Mineralogy*, pp. 24—5, 30—2,—4,—8, 52,—8,—9, 73. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 160,—8, 283—4, 308—9. Fox, *Reports of the Cornwall Polytechnic Society*, iv. pp. 86, 93. Henwood, *Cornwall Geol. Trans.*, v. pp. 7—15, 389—90, 464, *Tables I—XII.*, *Pl. I.*, *II.* Sorby, *Quarterly Journal of the Geol. Soc.*, xiv. p. 488, *Pl. XIX. Fig.* 118. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, p. 6. Salmon, *Mining and Smelting Mag.*, i. pp. 42—5; v. p, 260. Garby, *Cornwall Geol. Trans.*, vii. pp. 75,—6, 81,—3,—6,—7. Higgs, *Ibid*, vii. p. 449. Maskelyne, *Proceedings of the Royal Society*, xiv. p. 400.)

"*Levant* afforded between 1830 and 1865 a profit of rather more than £200,000, but, the particulars are now unknown, as many of the accounts were accidently burnt."—Henry Borrow, Esq., of Truro, Purser of the Mine, MSS.

At *Botallack* several *lodes*, having different directions, yield, for the most part, tin-ore whilst in granite, but copper-ores when in slate.

"From 1802 to 1836 the mine was worked by five Adventurers only, who shared amongst them a clear profit of £34,000."

Mr. Richard Wellington of Chyandour, Accountant at the Mine, MSS.

The mine is still largely and profitably wrought by the original proprietary.

"From the beginning of 1836 to the end of 1865 the present Shareholders have paid for their "plant," and at intervals of diminished produce...... £ 18,250

obtained tin-ore	which realized ..	£321734	
,, copper-ores	,, ..	183011	
			504,745
and sold sundries (old materials, &c.) ..	,, ...		8,720
			£531,715

The working expenses (salaries, wages, materials, &c.) have	amounted to..	£405085	
,, Royalties (Dues)..................	,, ..	23602	
,, Dividends, paid to the Shareholders..	,, ..	102150	
,, Balance (nominal) in the Purser's hands	....	878	
			£531,715

Stephen Harvey James, Esq., Purser of the Mine, MSS.

The Saint Ives District. (Berger, *Geol. Trans.*, o.s., i. p. 152. Forbes, *Cornwall Geol. Trans.*, ii. pp. 181—5, 259—64, *Pl. V. VI.* Carne, *Ibid*, ii. p. 344. Lysons, *Cornwall*, p. ccxi. Michell, *Manual of Mineralogy*, p. 32 ; *Cornwall Geol. Trans.*, v. p. 19. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 160, 283, 306,–23, 511,—13. Henwood, *Cornwall Geol. Trans.*, v. pp. 16—26, 390—1, 435—6, —65, *Tables XIII.—XXIII.*, *Pl. II.*; *Ibid*, vii. pp. 179—84, *Table I.*, *Pl. VIII.* Penberthy, *Ibid*, vi. pp. 106—7. Sorby, *Quarterly Journal of the Geol. Soc.*, xiv. pp. 475,—93—4, *Pl. XVII. Fig.* 53—6. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 15, 19. Garby, *Cornwall Geol. Trans.*, vii. pp. 86—9. Salmon, *Mining and Smelting Magazine*, iii. pp. 139—48, *Fig.* 11—14; *Ibid*, v. pp. 260—1.)

The *Saint Ives Consolidated Mines*—worked in granite, on several separate *lodes*, as well as on (the *Carbona)* an excrescent mass of vein-stone connected with one of them, afforded

from 1827 to 1834	....	a profit of	£24,675[a]
,, 1835 ,, 1865	yielded 10,368 64 tons of tin-ore, which realized—at an average of £50 : 7 : 1 per ton— £522,100	which left ,,	86,503
,, ,,	the Lord's dues, salaries, wages, and cost of materials amounted to.... 435,597		
		Net profit....	£111,178

Mr. John Vivian, Accountant at the Mine, *Mining and Smelting Magazine*, iii. pp. 146—8, MSS.

[a] The accounts for this period were accidentally burnt.

The extraordinary richness of this comparatively

In the *Providence Mines* several *lodes* yield copper-ores, accompanied—in one instance by a small quantity of pitch-blende,[a] —in the hornblendic slates; but in the granite they as well as (the *Carbona)* an excrescence of rich vein-stone, adjoining the northern side of *Wheal Laity north (branch) lode*, afford tin-ore alone.

The Capital invested from 1832 to 1848 amounted to.............. £11,570

From 1832 to 1865 the mines gave

4606·23 tons of tin-ore, which { (at an average of } £61 : 8 : 7 per ton) realized ..	£344388		
9720·00 „ copper-ore, „ 5 : 19 : 9 „ „	58220		
·97 „ pitch-blende, (at from 6*s.* to £2 per cwt.)	26		
Sundries	2733		
	———	405,367	
		£416,937	

The salaries, wages, materials, &c. during the same period amounted to	£312071	
„ Royalty *(Dues)* .... „ „	14780	
„ Shareholders received ...... „ „	90020	
„ Balance in the Purser's hands „ „	66	
	———	£416,937

"The success of this Adventure may be mainly attributed to the judicious policy of the Lords,—Mr. Praed, the Basset family, Mr. Stephens, and Mr. Davies Gilbert,—in giving up their Dues for a time,[b] which enabled the Shareholders to prosecute the mines and bring them to their present profitable state."

General Statements, circulated amongst the Shareholders, by Samuel Higgs, Esq., Purser of the Mines.

The Gwinear District. (Hitchins, *Phil. Trans.*, xci. (1801) pp. 159—64, *Pl. XI.* Berger, *Geol. Trans.*, o.s., i. pp. 169, 171—7. Lysons, *Cornwall*, p. ccix. William Phillips, *Geol. Trans.*, o.s., ii. pp. 146—52,—57,—60, *Pl. VI. Fig.* 6,—*VIII.* 1, 2. De Luc, *Geological Travels*, iii. p. 277. Hitchins & Drew, *History of Cornwall*, ii. p. 556. Carne, *Phil. Trans.*, xcvii. (1807) pp. 293—5, *Pl. XVIII.; Cornwall Geol. Trans.*, i. pp. 99—102; ii. pp. 105,—6,—8,—10,—13,—14,—20—4, *Pl. III. Fig.* 17; *Ibid*, iii. pp. 69, 79. Michell, *Manual of Mineralogy*, p. 12. Moyle, *Annals of Philosophy*, v. p, 36; *Ibid*, viii. p. 448. Edmonds, *Cornwall Geol. Trans.*, iii. p. 332. Gregor, *Ibid*, p. 338. Boase, *Ibid*, iv. pp. 309—10,—47—8. De la Beche, *Report on the Geology of Cornwall*, &c., p. 306. Henwood, *Proceedings of the Geological Society*, i. p. 405; *Cornwall Geol. Trans.*, v. pp. 35—42, *Tables XXXIII—XLII.*, *Pl. III. IV.* Rundell, *Ibid*, vii. pp. 37,—8. Salmon, *Quarterly Journal of the Geol. Soc.*, xvii. pp. 517—22.)

a Considerable quantities of the same ore had been previously obtained at *Wheal Trenwith*, an adjoining mine.—Henwood, *Cornwall Geol. Trans*, v. p. 19, Note.

b From March, 1840, to May, 1849, amounting altogether to about £4,000.

small spot, evoked a spirit of speculation ; at least as

At *Wheal Alfred* two *lodes*—having different directions, and traversing, as well the clay-slate, as the *elvan* intersecting it,—were wrought from 40 to 130 fathoms deep, by *bottom-stopes*. Between 1804 and 1815 they afforded

83,337 tons of copper-ore, which (at an average of £8 : 11 : 8 per ton) realized		£715,229
The Salaries, wages, materials, &c., amounted to	£504175	
,, Royalties (*Dues*, one-tenth) ,, ...	71523	
,, Profits shared by the Adventurers ,, ...	139531	
		£715,229

From Accounts obligingly furnished by George M. Millett-Davis, Esq., of Treneere.

The *Alfred Consolidated Mines*—which adjoin *Wheal Alfred* and were worked in similar rocks—yielded—from September, 1844, to February, 1861—

42,320·5 tons (*Avoir.*) of copper-ore which (averaging £6 : 18 : 1 + per ton) realized	£292262	
blende, which realized	719	
lead-ore ,, ...	115	
tin-stone ,, ...	56	
		£293,152
The Salaries, wages, materials, &c., ... amounted to	£179000	
,, Royalties (*Dues*) .... ,,	16104	
,, Profits divided amongst the Shareholders ,,	98048	
		£293,152

For this Account,—prepared by Mr. T. W. Robinson, Purser of the Mine,—the Author is indebted to Mr. J. Sampson Courtney, of Poltair.

At *Godolphin (Bridge)* the copper-ores,—obtained, within ninety fathoms of the surface, from different parts of one *lode*, in the slate-formation,—afforded, early in the present century, a net profit of £66,000.

William Williams, Esq., of Tregullow, MSS.

The Helston District. (Carew, *Survey of Cornwall*, pp. 13, 153. Borlase, *Natural History of Cornwall*, p. 161. Jars, *Voyages Métallurgiques*, III. p, 194. Klaproth, *Mineralogical Observations*, p. 31. De Luc, *Geological Travels*, III. pp. 270,—3. Hitchins & Drew, *History of Cornwall*, II. p. 116. C. S. Gilbert, *Historical Survey of Cornwall*, II. p. 760. Sedgwick, *Cambridge Phil. Trans*, I. pp. 111—14,—29. *Carne*, *Cornwall Geol. Trans.*, I. p. 102; *Ibid*, II. pp. 66—119; *Ibid*, III. p. 77. Fox, *Ibid*, II. *Pl. II.*; *Ibid*, III. p. 318; *Phil. Trans.*, CXX. pp. 407,—11. Hawkins, *Cornwall Geol. Trans.*, II. pp. 31, 380. Forbes, *Ibid*, II. pp. 185—9. T. F. Barham, *Ibid*, III. p. 151. Michell, *Manual of Mineralogy*, p. 71. Moyle, *Cornwall Geol. Trans.*, II. pp. 406,—11; *Annals of Philosophy*, VI. p. 90. Von Oeynhausen & von Dechen, *Phil. Mag. & Annals*, V. pp. 243,—6. Boase, *Cornwall Geol. Trans.*, IV. pp. 348—55; *Primary Geology*, p. 56. Richard

fierce and indiscriminating as that too frequently

Thomas, *Mining Review*, III. p. 30. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 162,—62,—71,—5, 284, 307,—28,—41. Henwood, *Edinburgh New Phil. Journal*, XXII. p. 154; *Cornwall Geol. Trans.*, V. pp. 43—56, 394, 467—8, *Tables XLIII.-- XLVIII.*, *Pl. V.; Reports of the Royal Institution of Cornwall*, XLI. pp. 22—3; *Annales des Mines*, 5me Série, XVI. pp. 571—3. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 2, 15, 16, 19, 21,-2,-3. Salmon, *Mining and Smelting Magazine*, II. pp. 14—18, 84—7; *Ibid*, V. pp. 287, 328.)

Wheal Vor—for many years the richest tin-mine in Cornwall—was worked mostly in slate, but to some extent in the granite also. The principal operations were confined to one *lode;* but other *lodes*, as well as metalliferous *floors*, which extended from one of them to another, were likewise wrought,

The mine, which had been worked, at least twice, before, was reopened in 1810, and prosecuted without interruption until 1847. As late as 1850, indeed, the *(leavings)* poorer ores, previously brought to the surface, were still *(dressed)* treated with advantage.

"From 1822 to 1850 the profit, divided amongst the shareholders amounted to £119,346."—John Kendall, Esq., Banker of the Company, MSS.

In 1853 operations were resumed; but in 1860 the deeper works were once more abandoned. At *Wheal Metal* immediately south, however, a parallel *lode* still yields great profit.

During the thirteen years 1853—1865, the mine has afforded

5167·3 tons of tin-ore, which (at an average of £68 : 15 : 6 per ton have realized..	£355387	
To March, 1860, the loss amounted to	194326	
		£549,713
The Salaries, wages, materials, &c., have amounted to..	£471029	
" Royalties *(Dues)* .... " ..	18110	
" Profit from March, 1860, to December, 1865.... ...... " ..	59574	
		£549,713

George Noakes, Esq., F.G.S., Chairman of the Company, & Mr. William Argall, Accountant at the Mine, MSS.

The Camborne and Illogan District. (Borlase, *Natural History of Cornwall*, pp. 168—70, *Pl. XVIII. Fig.* 1, 2. Pryce, *Mineralogia Cornubiensis*, pp. 170—2, *Pl. IV.* Jars, *Voyages Métallurgiques*, III. p. 221. Klaproth, *Mineralogical Observations*, pp. 27, 31, 61—6. Warner, *Tour through Cornwall*, pp. 131—5. Berger, *Geol. Trans.*, O.S., I. pp. 146,—54,—66,—70. De Luc, *Geological Travels*, III. pp. 286—94. William Phillips, *Geol. Trans.*, O.S., II. pp. 152—5, *Pl. VII. Fig.* 2; *Phil. Mag. & Annals*, II. p. 286. Rule, *Cornwall Geol. Trans.*, I. p. 225; *Ibid*, VII. pp. 161—3. Lysons, *Cornwall*, p. CCIX. Hitchins & Drew, *History of Cornwall*, II. p. 140. Richard Thomas, *Survey of the Mining District from Chasewater to Camborne*, pp. 30—77.

displayed in this country under the like circum-

Sedgwick, *Cambridge Phil. Trans*, I. p. 122. Carne, *Cornwall Geol. Trans.*, II. pp. 95—9, 102—5, *Pl II. Fig.* 9,—*III. Fig.* 16; *Ibid*, III. p. 84. Forbes, *Ibid*, II. pp. 189—91. Hawkins, *Ibid*, pp. 376—82; *Ibid*, IV., p. 6. Pendarves, *Ibid*, III. pp. 333—4. Michell, *Manual of Mineralogy*, pp. 20, 35—6, 52. Faraday, *Phil. Mag. & Annals*, II. p. 287. Fox, *Cornwall Geol. Trans.*, II. pp. 20,—3, *Pl. I.; Ibid*, III. pp. 318,—19,—23,—7; *Phil. Trans.*, CXX. pp. 404,—10,—11,—12; *Reports of the Cornwall Polytechnic Society*, IV. pp. 85,—91—2; *Ibid*, XIV. pp. 1—3; *Reports of the British Association*, 1834, p. 572;—1837, pp. 135—7;—1840, pp. 309—19;—1857, pp. 96—101. Boase, *Cornwall Geol. Trans.*, IV. pp. 311—12; *Primary Geology*, pp. 184,—90. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 176, 288, 306,—24, *Pl. VII., VIII., IX.* Henwood, *Phil. Mag. & Annals*, X. p. 360; *Reports of the British Association*, VI. 1837, p. 74; *Cornwall Geol. Trans.*, V. pp. 57—68, 395—6, 432—4,—68—9, *Tables XLIX.-- LVII., Pl. V., VI., VI.**; *Proceedings of the Royal Society*, IV. p. 317; *Reports of the Royal Institution of Cornwall*, XLI. pp. 22—3; *Annales des Mines*, 5me Série, XVI. pp. 571—3. Leifchild, *Encyclopædia Britannica*, XV. pp. 223—4. Sorby, *Quarterly Journal of the Geol Soc.*, XIV. p. 474. Garby, *Cornwall Geol. Trans.*, VI. pp. 194—5; *Ibid*, VII. pp. 73—4, 82—92. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, p. 6, *Pl. I., II., III.* Pearce, *Reports of the Royal Institution of Cornwall*, XLIII. p. 35. Salmon, *Mining and Smelting Magazine*, I. pp. 46—7, 316—18,—84 —8, *Pl. V.; Ibid*, II. pp. 74—8, 300—1; *Ibid*, III. pp. 82—9; *Ibid*, V. p. 329. Matthews, *Ibid*, II. p. 337, *Report of Commissioners on Mines in Great Britain* (Appendix B) Sections of *Condurrow* and *East Pool.)*

Dolcoath has been worked—with but one short interval—from beyond memory to the present time,—in both the granite and slate, as well as in the *elvan* (felspathic and quartzose porphyry) intersecting them,—on several *lodes*; which have yielded native silver *(Ante*, pp. 112—13), together with several ores of silver, nickel, and cobalt; but have afforded, and yet continue to afford, the ores of copper and tin in much greater abundance.

Dates.	Value of ores sold.	Royalty (*Dues*) paid.	Profits divided.	Calls.
From June 1800, to end of 1819..	£1,285,575	£54,343	£92,636	£45,252
„ end of 1819 „ Apr. 1835..	767,282	32,236	61,390	
„ April, 1835 „ Oct. 1849..	289,665	*Dues* given up	Neither *dividends* nor *calls*	
„ Oct. 1849 „ end of 1865..	745,310	32,776	145,039	
Totals........	£3,087,832	£119,355	£299.065	
		Calls	45,252	
		Net Profit..	£253,813	

Amount of Royalty *(Dues)* given up by the Lords.... £28,347.

" A tradition remains that in 1788 *(Ante*, p. 146, Note) the aggregate produce,

stances. For—with little regard to the characters of

—mostly of copper-ore,—had already realized *two millions* Sterling; but in that year the Adventurers—believing they had extracted everything worth removal—abandoned the mine; which had reached a depth of 185 fathoms. In 1800, however, operations were resumed; and—with the aforegoing results—they have been continued until now (1866)."

Captain Charles Thomas, Manager and Purser of the Mine, MSS.

Mr. Pryce's section of the works (*Mineralogia Cornubiensis, Pl. IV.*) published in 1778, shows a depth of rather less than 90 fathoms. His *Prospectus* (of which a copy—perhaps the only one remaining—is in the Author's possession) states, however, that "it is now three and twenty years since [he] first attended the transactions of the most capital copper mine (Dol-Coath or Bullen-Garden) in this county, which [he] was authorized to do by holding a small part in it; * * * during which time [he] made such enquiries and observations, as furnished a large share of the present materials. By so doing in two or three years they increased on [his] hands: [he] had therefore no better method to pursue, than to throw them into the form of a book." It would seem, from this, that the section was made about 1758.

Mr. Rule's well-known section—published (*Pl. VIII.*) in Mr. De la Beche's *Report on the Geology of Cornwall, Devon, and West Somerset*—was prepared in 1824, when the mine had reached a depth of nearly 240 fathoms.

From (?) 1758 to 1788,	therefore,	the works had been deepened	(by *bottom-stopes* a)	95 fms.;	and
,, 1800 ,, 1824,	,,	,,	(,, *shafts*)	55 ,,	.

They are now 340 fathoms deep.

The Carn Brea Mines yield the ores of tin and copper, on several *lodes*, which are wrought in the granite and slate formations, as well as in the *elvan-courses* which are common to both. In the course of thirty-one years (1834—1864) the shareholders have realized profits, which—varying from £2,000 to £20,000 per annum,—have amounted to £273,500.

"The cost of acquisition of the mines, and the expenses of working, up to the payment of Dividend, was £15,000.

"Besides the Dividends paid, the Mines' produce created the plant," now valued, as if to be broken up, at £40,000, but which must have cost nearer £100,000."

Thirty-fifth Report of the Directors; *presented at the Yearly Meeting of the Adventurers*, 27th May, 1865.

For this document the Author is indebted to

R. H. Pike, Esq., Purser of the Mines.

North Roskear and Wheal Crofty are prosecuted, on different *lodes*, in rocks composed chiefly of felspar and hornblende; irregularly sprinkled with quartz, and—at times—with calcareous matter.

Early in the last century a profit of about £45,000 was made from copper-ores obtained at shallow *levels* towards the east.

a Pryce, *Mineral. Cornub.*, p. 161. Carne, *Cornwall Geol. Trans.*, III. p. 69. Rule, *Ante*, p. 146, Note.

the *lodes*—and the nature of the rocks,—mines were

From the beginning of 1818 to the end of 1853 the mines have afforded—

tons			per ton			
142,953·8	of copper-ore which	(sold at an average price of	£5 18 7)	realized	£847,808	
144·2	,, tin-ore ,,	,,	44 6 8)	,,	6,395	
26·1	,, blende ,,	,,	2 7 11)	,,	63	
330·8	,, arsenic ,,	,,	2 13 4)	,,	884	
						£855,150
Sundries (old materials, &c.) sold						4,100
Calls, at intervals of diminished produce						11,200
						£870,450
The salaries, wages, materials, and other working expenses				amounted to	£717,393	
,, Royalties *(Dues)*				,,	52,378	
,, Dividends shared amongst the Adventurers				,,	100,679	
						£870,450

William Cock Vivian, Esq., Manager of the Mines, MSS.

West Wheal Seton has been worked from 1844 until now (1866) in an *elvan-course*, seen underground in *Wheal Seton* and at the surface in *North Roskear*, as well as in the same slate-rocks, and on the same *lodes*, as *East Wheal Crofty*, *Wheal Crofty*, and *Wheal Seton*, with the following results;—

Proceeds of tin and copper ores sold			£454,836
Amount of salaries, wages, &c.	£186,768		
,, Machinery and materials	79,418		
		£266,186	
Royalty *(Dues)* paid the Landowner		30,322	
Profit divided amongst the Adventurers		158,328	
			£454,836

"The *Plant* is worth at least £5,000."

Benjamin Matthews, Esq., of Saint Day, Purser of the Mine, MSS.

West Wheal Basset, in the granite of Carn Kye, has been largely wrought on four—and less extensively on several other—*lodes*, with the undermentioned results.

In 1850—2 the outlay amounted to					£9,000
From January, 1850, to March, 1856, the mine yielded					
tons (*Av.*)		per ton			
78,216	of copper-ore, which (averaging	£6 1 11+)	realized	£476,838	
26	,, tin-ore, ,, ,,	55 13 4+)	,,	1,464	
	tin-stone, ,, ...		,,	7,202	
Sundries (old materials, &c.)			,,	1,471	
					486,975
					£495,975

The payments for	Salaries, Wages, &c., amounted to		....	£210,598
,,	Machinery, tools, & materials	,,	....	77,559
,,	Royalty *(Dues)*	,,	....	31,233
,,	Sundries (Rates, taxes, &c. .	,,	....	8,357
	Carried forward			£327,747

opened on all sides. Within twenty years more

	Brought forward........		£327,747
The Profits divided amongst the Adventurers	have been..	£159,600	
Costs of Law-suits with the Shareholders in an adjoining mine	,, ..	7,621	
Balance of Cash in the Treasurer's hands amounted to		1,007	
			168,228
			£495,975

The Redruth and Gwennap District. (Borlase, *Natural History of Cornwall*, pp. 174, 205. Pryce, *Mineralogia Cornubiensis*, pp. 33, 192, 231,—80, *Pl. VII.* Jars, *Voyages Métallurgiques*, III. pp. 192—4. Klaproth, *Mineralogical Observations*, pp. 8, 10, 25—8, 30, 59. Maton, *Observations on the Western Counties*, I. pp. 242—8. Thomson, *Annals of Philosophy*, II. p. 350. De Bournon, *Phil. Trans.*, XCI. p. 169. Chenevix, *Ibid*, XCI. p. 193. Gregor, *Ibid*, XCIX. p. 195, Warner, *Tour through Cornwall*, pp. 176,—90. Berger, *Geol. Trans.*, O.S., I. pp. 146,—62—6,—70—7. De Luc, *Geological Travels*, III., p. 325. William Phillips, *Geol. Trans.*, O.S., II. pp. 155—6, *Pl. VI.*, *Fig.* 1. Smith, *Ibid*, IV. p. 58. Williams, *Ibid*, pp. 142—5, *Pl. VI.*, *Fig.* 1. Hitchins & Drew, *History of Cornwall*, II. p. 305. Richard Thomas, *Survey of the Mining District between Chasewater to Camborne*, pp. 5—76; *History of Falmouth*, pp. 31—3. Rees, *Cyclopædia*, XXIII., Article Mining. Carne, *Cornwall Geol. Trans.*, I. p. 103; II. pp. 76—9, 82—90, 121; III. pp. 65,—7, 74,—7,—9, 81,—3,—4. Fox, *Ibid*, II. pp. 20—1,—5, *Pl. I.*; III. pp. 314—17,—24—6; *Phil. Trans.*, CXX. pp. 401,—7,—10,—11,—13,—14; *Reports of the Cornwall Polytechnic Society*, IV. pp. 90—6, 124; XIV. p. 1; *Reports of the British Association*, 1834, p. 572; 1837, p. 135; 1840, p. 309; 1857, p. 96. Sedgwick, *Annals of Philosophy*, IX. p. 249. Moyle, *Cornwall Geol. Trans.*, II. pp. 205—6. Boase, *Ibid*, IV. pp. 290—2, 304—7; *Primary Geology*, pp. 181,—5,—8. Bennetts, *Phil. Mag. & Annals*, III. pp. 17—18. Burr, *Practical Geology*, pp. 286—8, *Pl. IV. V.*; *Mining Review*, III. pp. 226,—32. De la Beche, *Geology of Cornwall, &c.*, pp. 176—7, 305—7,—10,—24,—9,—33,—7,—40, 404. Henwood, *Proceedings of the Geological Society* I. pp. 405—6; *Cornwall Geol. Trans.*, III. pp. 203—7, 329—31; IV. pp. 57—60; V. pp. 69—92*, 396—9, 417—26,—32—4,—70—1, *Tables LVIII.—LXIX.*, *Pl. VII.*, *VIII.* Michell, *Manual of Mineralogy*, pp. 27—40, 52, 63, 85; *Cornwall Geol. Trans.*, III. p. 338. Evan Hopkins, *Connexion of Geology with Terrestrial Magnetism*, p. 50, *Pl. VIII.* Francis, *Gwennap*, pp. 4, 11, 21, 38, 63, 94. (Captain) William Francis, *Reports of the Cornwall Polytechnic Society*, XIV. p. 4. Sorby, *Quarterly Journal of the Geol. Soc.*, XIV. pp. 485—6,—92—4, *Pl. XIX.*, *Fig.* 107-8-9. Garby, *Cornwall Geol.*

than one hundred Companies were organized for

Trans., VI. p. 265; VII. pp. 73—5, 81—92. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 4, 14, 16, 20,—2. Salmon, *Mining and Smelting Magazine*, I. p. 316; II. pp. 140—8; V. p. 328. Smyth, *Ibid*, V. pp. 193—6; *Reports of the British Association*, 1864, Part II. p. 70. Lyell, *Ibid*, p. LXV. Miller, *Ibid*, Part II. p 35. Pearce, *Journal of the Royal Institution of Cornwall*, I. p. 53. *Report of Commissioners on Mines in Great Britain*, Appendix B, Section of Workings in *Poldice (St. Day United Mines)*. *Ante*, p. 114.)

At *Wheal Buller*, one of the *lodes*, wrought in granite, from July, 1849, to May, 1861, yielded—

tons		per ton		
82,609·4 of copper-ore, which (averaging		£5 15 8+) realized	£477,886	
621·8 ,, tin-ore,	,, ,,	69 9 2+) ,,	43,180	
beside tin- *(stuff)* stone ,,	....	,,	2,235	
				£523,301
The Royalties *(Dues*, for great part of the time 1-16th, but towards the last 1-30th of the produce), together with the salaries, wages, materials, &c., amounted to			£279,909	
,, Profit divided amongst the Shareholders	,,	..	243,392	
				£523,301

Richard Davey, Esq., M.P., F.G.S., of Bochym, MSS.

Tresavean—wrought in granite on a single *lode*—yielded, from the beginning of 1828 to October, 1838, copper-ores which realized £720,338

The Salaries, wages, materials, and other working costs, meanwhile, amounted to			£326,203	
,, Royalty *(Dues)*	,,	..	36,331	
,, Profit shared amongst the Adventurers	,,	..	348,456	
,, Balance remaining in the Purser's hands	,,	..	9,348	
				£720,338

Mr. Hugh Phillips, Accountant at the Mine, *Cornwall Geol. Trans.*, V. p. 88*.

The granite of Carn Marth, the slate on its northern, eastern, and southern slopes, and the *elvan-courses* common to both, are alike traversed by many *lodes*; which yield, generally, tin-ore near the surface, but copper-ores at greater depths.

The following list of profits made in the neighbourhood from 1800 to 1840 has been compiled from the books of the respective mines; all which have since been abandoned.

Mines.	Rocks.	Profits.
Wheal Damsel	Granite	£250,000
Wheal Jewel	,, ...	400,000
Wheal Gorland	,, ...	60,000
Treskerby	Granite, slate, and *elvan*	105,000
Ting Tang	Slate and *elvan*	42,000
Wheal Maid	Slate	200,000
		£1,057,000

Sir William Williams, Bart., of Tregullow, MSS.

working copper-mines on the shores of Lake Superior.

The *Consolidated Mines* have been worked in the clay-slate and in the *elvans* which traverse it; on several *lodes*, consisting chiefly of quartz; mixed, near the surface, however, with tin-ore and the rarer compounds of copper; but, at greater depths, with copper-pyrites only.

The cost of bringing the mines into profitable condition amounted to	£ 65,000	
In twenty-one years (1819—1840), however, they yielded—		
tons 299,184·8 of copper-ore, which (averaging per ton £7 0 4+) realized	2,099,485	
At the end of that term the *Plant*, stores, &c. .... ,,	90,000	
		£2,254,485
During the same period, the Salaries, wages, and Materials amounted to	£1,611,290	
,, ,, Royalties *(Dues)* ,,	87,153	
,, ,, Sundries (expenditure at the *United Mines*, &c.) ,,	75,886	
,, ,, Dividends shared amongst the Adventurers ...... ,,	480,156	
		£2,254,485

Compiled from Accounts of the Mines, by HENRY THOMAS, ESQ., F.G.S., of London.

At *Wheal Unity*—worked late in the last, and early in the present, century—in the slate series immediately east of, and on the same copper-*lodes* as, *Wheal Gorland*, the Adventurers shared a net profit of	£370,000
beside maintaining operations on parallel tin-*lodes* in rocks of the same system at *Poldice;* an adjoining mine, wrought, at the same time by the same parties, at a loss of nearly	130,000

The total profit at *Wheal Unity*, therefore, approached half a million Sterling.

RICHARD DAVEY, ESQ., M.P., F.G.S., of Bochym, MSS.

Between *Carnon* and *Point*—near the head of Restronguet-creek a navigable branch of Falmouth harbour—a rich and extensive deposit of (detrital) *stream-tin-ore* has been wrought, at intervals, for great part of a century.

The earlier works— protected, as well from the river as the tide, by a strong embankment, and open to the day [a]—were abandoned in 1811—12, after having yielded a profit [b] of rather more than £50,000.

MR. WILLIAM TREBILCOCK, (of *Carharrack*), an Accountant at the Works, MSS.

In 1824—5 a shaft was sunk immediately north of the creek; and (galleries) *levels*—which at one and the same time grazed the *(shelf)* slate beneath, traversed

[a] "For removing the *overburthen*, of mud, sand, and gravel, the workmen received two shillings and tenpence per cubic fathom."—MR. WILLIAM TREBILCOCK, MSS.

[b] "The CARNON Stream Works * * * are nearly a mile in length and three hundred yards in breadth. The number of men and boys employed amounted to at least one hundred and fifty; * * * the proprietors gaining at least three thousand pounds per annum."
MATON, *Observations on the Western Counties* (1794—6), I. p. 174.

Of these, however, great numbers have been from

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the *tin-ground,* and skirted the overlying beds *a*—were extended towards the south. This experiment afforded, in two or three years, a profit of £28,000.

Mr. Edmund Michell, of *Tresavean,* a Shareholder, MSS.

Operations were resumed in 1833, but so far down the inlet that, even at low-water, the surface was never dry. Through a mound of rubbish, purposely heaped up in mid-channel, an iron-bound shaft was opened to the ore; and in *levels,* extended on all sides, people worked day and night, whilst ships passed and re-passed overhead. In 1843 the undertaking was abandoned.

The entire produce realized		£52,615
,, Working expenses amounted to about	£65,692	
,, Royalties *(Dues)*	2,923	
		68,615
A loss was therefore incurred of some		£16,000

Mr. Nicholas Sampson Cloak, Accountant at the Mine, MSS.

The Saint Agnes and Perran-zabuloe District. (Tonkin, *Notes to Carew's Survey of Cornwall*—Lord De Dunstanville's Edition, pp. 33—4,—6. Borlase, *Natural History of Cornwall,* pp. 76, 110,—65,—88,[b] 207. Pryce, *Mineralogia Cornubiensis,* pp. 20, 58, 84, 107. Klaproth, *Mineralogical Observations,* pp. 7, 9, 21, 58. Warner, *Tour in Cornwall,* p. 291. Maton, *Observations on the Western Counties,* I. pp. 248—54. Berger, Geol. Trans. O.S., I pp. 155,—62,—64,—71. Gregor, *Annals of Philosophy,* O.S., VIII. p. 277. William Phillips, *Geol Trans,* O.S., IV. pp. 129—37; *Pl. VII. Fig.* 8. Lysons, *Cornwall,* pp. CCV.,—VIII. Polwhele, *History of Cornwall,* IV. pp. 133—4. Conybeare, *Geol. Trans.,* O.S , IV. pp. 401—3 ; *Pl. XXIII. Fig.* 2, 3. Hitchins & Drew, History of Cornwall, II. p. 18. C. S. Gilbert, *Historical Survey of Cornwall,* I. pp. 219,—59. Rashleigh, *British Minerals,* I. pp. 6, 9—13, 38, 40,—8, 50; II. p. 19. Sedgwick, *Cambridge Phil. Trans.,* I. pp. 131—2. Carne, *Cornwall Geol. Trans.,* I. pp. 120—21; II. pp.

a Similar operations, on a small lateral extension of the same deposit below Perran Wharf, permitted the decomposition of incumbent vegetable matter, and the consequent escape of inflammable gas; of which explosions sometimes scorched the workmen.

b " The richest tin-mine I have ever heard of, as to the quality of the ore, is one in the parish of St. Agnes * * * called Polberou. Several parallel and contiguous veins, mostly of large-grain crystals, make the treasure of tin in such quantity, that, in the year 1750, they could not get horses enough to carry the tin from the mine to the melting-house, but carried it in ploughs " (wains drawn by oxen), " a very unusual sight (though doubtless a more effectual and easy draught, where the ways will admit of wheels. Great part of the ore was so rich that it needed not to be stamped, and the lode was so large that it afforded vast rocks of tin; one rock, in March, 1750, was brought to Killinick melting-house near Truro, which weighed 664 pounds, and it brought 11½ for 20, in the stone; [another] weighed 1,200 pounds. It has been judged that the late Mr. Denithorne, who had the whole adventure, and worked it at his sole expense, in a few years last past, got at least £40,000 clear by the mine."

Borlase, *Natural History,* p. 188.

time to time abandoned, after short—and, perhaps,

55, 74, 80,—6—92,—4—5,—7, 103,—4,—8,—11—18,—20,—6—7; III. pp. 69, 77, 229. John Michell, *Manual of Mineralogy*, pp. 9, 11, 12, 19, 20,—5, 32,—7, 61—2, 73, 85. Hawkins, *Cornwall Geol. Trans.*, III. p. 11. Fox. *Phil. Trans.*, cxx. pp. 401,—11,—13; *Cornwall Geol. Trans.*, III. p. 314. von Oeynhausen & von Dechen, *Phil. Mag. & Annals*, v. pp. 169—70. Boase, *Cornwall Geol. Trans.*, IV. pp. 293—304,—97—405; *Primary Geology*, pp. 169,—87. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 162,—77—8, 283,—4,—8, 305,—16,—17,—27,—36, 511. Sedgwick & Murchison, *Geol. Trans.*, N.S., v. pp. 667—8. Davey, *Cornwall Geol. Trans.*, IV. pp. 484—5. Henwood, *Proceedings of the Geol. Soc.*, I. p. 405, *Reports of the British Association*, VI. Part II. p. 74; *Edinburgh New Phil. Journal*, XXII. p. 155; *Cornwall Geol. Trans.*, v. pp, 93—114, 399—400,—72—3, *Tables LXX.—LXXXIII. Pl. IX. Fig.* 1—9; *Reports of the Royal Institution of Cornwall*, XXV. pp. 54—6. Whitley, *Ibid*, pp. 34—7. Richard Thomas, *Mining Review*, II. pp. 265—74; *Cornwall Geol. Trans.* v. pp. 98, 111—12. Robert Michell, *Ibid*, p. 268. Williams, *Ibid*, VI. p. 131. Tweedy, *Reports of the Royal Institution of Cornwall*, XXI. p. 44. Haslam, *Perran-zabuloe*, pp. 40—1. Garby, *Cornwall Geol. Trans.*, VII. pp. 76—9, 81—8, 21—2. Smyth, *Ibid*, pp. 332—5. Arundell, *Pick & Gad*, I. pp. 2, 51—4, 111. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 19, 20. Pearce, *Reports of the Royal Institution of Cornwall*, XLIII. p. 34. Blight, *Churches of West Cornwall*, pp. 89—90. *Ante*, pp. 110—11.)

Wheal Towan—worked until 1815, in slate, and mostly on one *lode*—yielded a profit of £127,000; of which the late R. A. Daniel, Esq., of Trelissick in Feock, received three-quarters.

Captain Nicholas Vivian—sometime Manager of the Mine—MSS.

East Wheal Rose—wrought in clay-slate—yielded, between June, 1834, and April, 1855, lead and silver ores which realized.................... £799,588

The Salaries, wages, materials, &c., amounted to		......	£471,850	
,, Royalties *(Dues)*.............	,,	......	53,178	
,, Profit (ranging from £2,944 to £52,928 per annum....	,,	......	274,560	
			————	£799,588

Edward Michell, Esq., of Mitchell Hill, near Truro, Purser of the Mine, MSS.

The St. Austell District. (Borlase, *Natural History of Cornwall*, pp. 96, 151,—62—3,—89,[a] 214. Pryce, *Mineralogia Cornubiensis*, pp. 32, 68,

[a] "The mine which has turned out the most gain, and the greatest quantity of tin yet known, is 'Polgooth' in the parish of St. Mewan, where it appears by the old books, that the adventurers have got £20,000 annually for a great number of years following."—*Letter from* Mr. W. Roswarn *of Truro*, Feb. 11, 1756. Borlase, *Natural History*, p. 189.

insufficient—trial; although many are still wrought

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123. Jars, *Voyages Métallurgigues*, III. pp. 108,—90. Klaproth, *Mineralogical Observations*, pp. 10, 13. Warner, *Tour in Cornwall*, pp. 96—102. Polwhele, *History of Cornwall*, III p. 10; IV. pp 133–5. Thomson, *Annals of Philosophy*, II. p. 347. Gregor, *Phil. Trans.*, XCV. p. 331; *Cornwall Geol. Trans.*, I. p. 224. Maton, *Observations on the Western Counties*, I. pp. 151—69. Rashleigh, *British Minerals*, I. pp. 1—8, 11, 17, 48; II. p. 20, *Pl. XXI.*; *Cornwall Geol. Trans.*, II. pp. 281—4. Berger, *Geol. Trans* , O.S., I. pp. 125,—62,—9,—79. Héron de Villefosse, *Richesse Minéral*, II. p. 354. De Luc, *Mineralogical Travels*, III. pp. 339—49. Lysons, *Cornwall*, pp. CCV.,—XI. *Pl. II.* Sedgwick, *Cambridge Phil. Trans.*, I. pp. 104—5,—8; *Proceedings of the Geol. Soc.*, I. p. 283; *Phil. Mag. & Annals*, IX. p. 284; *Quarterly Journal of the Geol. Soc.*, VIII. pp. 9—11; *Geol. Trans.*, N.S., III. pp. 482—4. Smith, *Geol. Trans.* O.S., IV. pp. 404—8. Hitchins & Drew, *History of Cornwall*, II. pp. 61—71. C. S. Gilbert, *Historical Survey of Cornwall*, I. pp. 219,—27,—48. Hawkins, *Cornwall Geol. Trans.*, I. pp. 143—53, *Pl. V.*; II. pp. 285—9; IV. pp. 475—80. Majendie, *Ibid*, I. p. 237. Carne, *Ibid*, II. pp. 87—9, 90—4, 103—7, —11,—18,—27. Michell, *Manual of Mineralogy*, pp. 21,—5,—8, 39, 50—1, 62—4, 71,—3, 82,—5. Davis, *Mining Review*, IV. p. 111. von Oeynhausen & von Dechen, *Phil. Mag. & Annals*, V. pp. 241–3. Colenso, *Cornwall Geol. Trans.*, IV. pp. 21—30, *Pl. I.* Boase, *Ibid*, pp. 235—52,—80—1, 379—82, 404; *Lond. Edin. & Dublin Phil. Mag.*, VII. pp. 379, 450; X. p. 350. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 81—3, 159—60,—81—3,—5,—9, 284,—8, 302—5,—10,—27—9,—32,—4,—46—7,—67, 401—3, 501,—61—2, 603—5, *Pl. X. XI.* Sedgwick & Murchison, *Geol. Trans.*, N.S., V. pp. 664—9. Winn, *Reports of the Royal Institution of Cornwall*, XXI. Henwood, *Edin. New Phil. Journal*, XXII. pp. 54,—6; *Reports of the Royal Institution of Cornwall*, XXI. pp. 54—6; *Cornwall Geol. Trans.*, IV. pp, 60—4; V. pp. 115—30, 400,—74. Richd. Taylor, *Ibid*, VI. p. 99. David Williams, *Ibid*, pp. 334—6. Stocker, *Reports of the Cornwall Polytechnic Society*, XX. pp. 77—96. Sorby, *Quarterly Journal of the Geol. Soc.*, XIV. pp. 86—7, 492—4, *Pl. XIX. Fig.* 111,—17,—19. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 16, 20—1. Arundell, *Pick & Gad*, I. pp. 2, 53, 108—9. Pearce, *Reports of the Royal Institution of Cornwall*, XLIII. p. 35; *Journal of the Royal Institution of Cornwall*, I. p. 224. R. H. Williams, *Reports of the Royal Institution of Cornwall*, XXXIX. p. 32; XLV. pp. 44—7, *Pl. V.*; Salmon, *Mining and Smelting Magazine*, V. p. 330; Maskelyne, *Proceedings of the Royal Society*, XIV. pp. 86—9, 392—400. *Ante*, p. 118.)

The *Crennis lode*—which was wrought in clay-slate, immediately beneath certain long-known fossiliferous strata,—afforded in

with reasonable prospects of success. But, amongst

		fms.		tons			per ton	
1811,	at less than	14	from the surface,	2,136·4	of copper-ore,	which (averaging	£9 8 9)	realized £20,132
1812,	when the mine was	22	deep,	10,109·3	,,	,,	8 8 7)	,, 53,139
1813,	,,	34	,,	6,304·5	,,	,,	6 19 9)	,, 70,300
1814,	,,	38	,,	10,551·2	,,	,,	9 1 4)	,, 95,679
1815,	,,	50	,,	7,160 6	,,	,,	5 17 9)	,, 42,145
1816,	(6 months)	,,	,,	2,985·8	,,	,,	5 14 8)	,, 17,121
				39,247,8	,,	,,	£7 12 1+)	,, £298516

The profit was about £120,000.

Wood (Hitchins & Drew's), *History of Cornwall*, ii. p. 70 (Abstract).

Whilst the Property-tax (of ten per cent.) continued, the *Dues* were (1-8 & 1-80) eleven-eightieths, but on its abolition (in 1814) they were reduced to one-eighth, of the produce.—William Petherick, Esq., of St. Austell, MSS.

The *Fowey Consolidated Mines* have been worked from 1815 until now (1866) on many *lodes*, in clay-slate, alternating, here and there, with thin beds of massive felspar.

From 1815 to 1842 they afforded

tons 234.486·4 of copper-ore, which (averaging about per ton £6 1 4) realized..			£1,422,634
The Landlords received as Royalties *(Dues)*	£95,611		
,, ,, for damage to the surface..	2,436		
		£98,047	
,, Machinery, materials, &c., cost.....................		237,706	
,, Salaries, wages, &c, amounted to..........	£902,191		
,, Medical attendance cost..................	4,694		
		906,885	
,, Profits divided amongst the Adventurers....	£173,914		
,, ,, deposited as a Reserve fund........	6,082		
		179,996	
			£1,422,634

"In 1842 the engines, tools, and materials on the mines were worth £60,000."

Petition to Parliament by Joseph Thomas Treffry, Esq. (Abstract).

The Caradon District. (Borlase, *Antiquities of Cornwall*, p. 173, *Pl. XII.*, *Fig* 1. Lysons, *Cornwall*, clxxxiv., 198, *Pl. VIII.* Mac Culloch, *Geol. Trans.*, o.s., ii. p. 169. C. S. Gilbert, *Historical Survey of Cornwall*, i. pp. 171—3, 247; ii. p. 479. Rogers, *Cornwall Geol. Trans.* ii. pp. 218—21. Bond, *Historical Sketches of East and West Looe*, pp. 203—16. Boase, *Cornwall Geol. Trans.*, iv. pp. 208—10. De la Beche, *Report on the Geology of Cornwall*, &c., pp. 159,—85. Whitley, *Geological Map of the Caradon Mining District.* Allen, *History of Liskeard*, pp. 4, 27, 33, 204, 394—402,—18—32. Thomas, *Remarks on the Geology of Cornwall and Devon*, p. 15. Arundell,

them all, no more than eight have hitherto given

Pick and Gad, pp. 3, 54, 108. Giles, *Cornwall Geol. Trans.*, VII. pp. 158,—98, 207. Salmon, *Mining and Smelting Magazine*, II. pp. 78—83, 342; III. p. 364; V. p. 331. *Ante*, p. 120, *Postea.)*

South Caradon is worked in the granite, on several *lodes*, which contain copper and its ores in abundance.

During the past thirty years (1836—65..	the sales have amounted to		£1,001,536
,, ,,	,, working expenses have been..	£675,088	
,, ,,	,, Royalties *(Dues)* ,, ..	54,931	
,, ,,	,, Profits ,, ..	271,517	
			£1,001,536

Peter Clymo, Esq., Manager and Purser of the Mine, MSS.

The Callington and Tavistock District. (Holinshed, *Chronicle* (Edit. 1837), II. p. 545. Polwhele, *Historical Survey of Devonshire*, I. p. 110; *History of Devonshire*, I. pp. 69—72; *History of Cornwall*, IV. pp. 133—5. Maton, *Observations on the Western Counties*, I. pp. 296—300. Berger, *Geol. Trans.*, O.S., I. pp. 120—2,—68,—73. Thomson, *Annals of Philosophy*, II. p. 351. Lysons, *Cornwall*, pp. CCVI.—X.; *Devonshire*, I. pp. CCLXXX.—XC. Taylor, *Geol. Trans.*, O.S., IV. pp. 147—52, *Pl. VIII.* Sedgwick, *Cambridge Phil Trans.*, I. p. 95. Carne, *Cornwall Geol. Trans.*, I. pp. 122—4; II. p. 104. Rees, *Cyclopædia*, XXIII. Article Mining; XXXII. Article Silver. C. S. Gilbert, *Historical Survey of Cornwall*, I. pp. 172—3, 219. Bond, *Historical Sketches of East and West Looe*, p. 110. Michell, *Manual of Mineralogy*, pp. 11 21,–8, 32,–3,-5, 79, 88,-9. Prideaux, *Transactions of the Plymouth Institution*, I. pp. 23,-5—30. Bray, *Borders of the Tamar and Tavy*, I. pp. 240, 310. Fox, *Cornwall Geol. Trans.*, III. pp. 314,–21. Boase, *Ibid*, IV. pp. 220-3; *Primary Geology*, p. 186. De la Beche, *Researches in Theoretical Geology*, pp. 219, 385; *Report on the Geology of Cornwall*, &c., pp. 61-2, 117,—19-22,—41-3,—56-7,—83-5, 296, 301-2, 401,—98; *Inaugural Discourse at the Government School of Mines*, p. 10. Burr, *Mining Review*, III. pp. 228,-32. John Phillips, *Palæozoic Fossils of Cornwall, Devon, and West Somerset*, pp. 198, 201. Tooke, *Mining Almanack* for 1849, pp. 241-9. Sedgwick & Murchison, *Geol. Trans.*, N.S., V. pp. 669–70,—85-6. Henwood, *Proceedings of the Geol. Soc.*, I. p. 405; *Cornwall Geol. Trans.*, IV. p. 25; V. pp. 131—42,—58, 400-1,—75-6, *Tables XCI.—VIII.*, *Pl. X.* Rowe, *Perambulation of Dartmoor*, pp. 8, 232,—91-8 (Moore, *Appendix I.)*, 249-57. Leifchild, *Encyclopædia Britannica*, XV. pp. 225-6. Ormerod, *Quarterly Journal of the Geol. Soc.*, XV. pp. 16-23, 189–90. Arundell, *Pick and Gad*, I. pp. 3, 51,—4, 105-6. Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, pp. 7, 8, 16, 20. Pengelly, *Reports of the British Association for* 1861, Part II. pp. 127–9; *Cornwall Geol. Trans.*, VII. p. 419. Salmon, *Mining and Smelting Magazine*, V. p. 331. *Report of Commissioners on Mines in Great Britain* (Appendix B), pp. 313–21. *Ante*, pp. 109-10,—14-15,—44.)

" *Gunnis Lake*—worked in granite, immediately west of the Tamar—afforded a profit of £37,000."—Sir William Williams, Bart., of Tregullow, MSS.

The Devonshire Great Consolidated Copper-Mines—which have been worked in clay-slate with the following results,—are still the richest copper-works in Europe.

dividends; and even of these seven only have

Years.	Copper-(pyrites) ore. Tons. *Av.*	Receipts.			Expenditure.				Profit.
		Proceeds.	Sundries.	Totals.	Salaries and Wages.	Materials and sundries.	Royalty (*Dues*)	Totals.	
		£	£	£	£	£	£	£	£
1855	401	4314	1024	5338	2605	7	—	2612	2726
6	13957	116069	2437	118506	30590	6154	8322	45066	73440
7	15118	93610	3252	96862	49110	15377	7189	71676	25186
8	15134	102933	3884	106817	57085	15661	7882	80628	26189
9	17410	101032	1473	102505	51810	14242	7628	73680	28825
1850	16204	104555	620	105175	49897	11683	7906	69486	35689
1	18155	117408	724	118132	52509	12344	8960	73813	44319
2	19894	118334	601	118935	51931	12605	9027	73563	45372
3	21931	147647	930	148577	68269	12992	10966	92227	56350
4	25598	153837	1586	155423	75115	15268	12117	102500	52923
5	24073	152489	875	153364	64862	14693	11686	91241	62123
6	25119	140844	1054	141898	63023	12991	10770	86784	55114
7	30278	159432	1465	160897	61777	10663	11625	84065	76832
8	26431	138357	2074	140431	53387	22448	11377	87212	53219
9	24729	119497	11861	131358	47572	26546	9557	83675	47683
1860	23981	115285	3598	118883	50084	18730	9288	78102	40781
1	22925	108366	2376	110742	43349	11052	9117	63518	47224
2	21898	103330	1446	104776	41595	8923	8521	59039	45737
3	25854	118480	1666	120146	42396	10256	9594	62246	57900
4	28176	130175	2035	132210	51420	14219	10504	76143	56067
5	27075	134796	3888	138684	56310	12923	11220	80453	58231
Totals	444,341	2,480,790	48,869	2,529,659	1,064,696	279,777	193,256	1,537,729	991,930

Abstract of the Annual Accounts, from the commencement of operations to the end of 1865; *printed for circulation amongst the Shareholders.*

On an average, therefore each ton of ore cost............ £3 9 3.
" " " was sold for .... 5 11 8.

For this important account the Author is obliged to Joseph Matthews, Esq., of Tavistock.

yet yielded profit to the shareholders.*

Wheal Friendship[a] is wrought in clay-slate; interlaid, at intervals, with thin beds of carbonaceous matter. The earliest and largest works were, in great measure, confined to one *lode*, but of late a second has been opened to advantage. Both are intersected by several *cross-courses;* one of which has afforded great quantities of lead-ore, both here and in *(Wheal Betsy)* an adjoining mine.

From the beginning of 1800 to the end of 1865 the returns were—

Copper-ore	145,803·1	tons *(Av.)*	which realized.. £1,371,954
Lead- „	1,170·4	„	
Tin- „	162·0	„	
Arsenic-„	4,342·7	„	

The machinery, materials, salaries, wages, &c., amounted to		£970,263
„ Royalties *(Dues)*....................	„	111,883
„ Profit divided amongst the Adventurers	„	289,808
		£1,371,954

JOSEPH MATTHEWS, ESQ., of Tavistock, Purser of the Mine.

* "Within the last twenty years, something over a hundred different companies have been organized for the purpose of mining on Lake Superior, and calls have been made on their stockholders to the extent of about thirteen million dollars (£2,708,333 Stg.); out of them all, only eight have ever made any dividends; not because of the price of copper, but for want of sufficient product. These eight companies have called for and returned the following amounts.—

		Assessments. dollars	£	*Dividends.* dollars	£
Pittsburg & Boston ..	Mining Company,	110,000	(22,917 Stg.)	2,160,000	(450,000 Stg.)
Minnesota ..	„	366,000	(76,250 „)	1,760,000	(366,667 „)
Quincy	„	200,000	(41,666 „)	700,000	(145,833 „)
Pewabic	„	75,000	(15,625 „)	380,000	(79,167 „)
National	„	110,000	(22,917 „)	280,000	(58,333 „)
Franklin	„	170,000	(35,417 „)	220,000	(45,833 „)
Central	„	100,000	(20,833 „)	150,000	(31,250 „)
Copper Falls.	„	490,000	(102,083 „)	60,000	(12,500 „)

Total { *Assessments* .... 1,621,000 (337,708 „)
{ *Dividends*............................. 5,710,000 (1,189,583 „)

Memorandum of the Smelters and Manufacturers of Copper; submitted to the Representatives of the United States, by S. T. SNOW, ESQ., of the Revere Copper Company.

a "STATEMENT OF RATE OF PROFIT PER CENT. ON RECEIPTS, AND PROPORTION OF DUES ON PROFIT.

	Number of years	Amount of Receipts	Amount of Cost.	Rate of Dues	Amount of Dues	Profit	Rate of Profit on Receipts	Proportion of Dues on Profit
		£	£		£	£	per cent.	per cent.
Consolidated Mines..	20	2,099,491	1,611,340	1-24	87,453	488,151	23·25	17·91
Wheal Friendship ..	7	148,354	112,251	1-12	12,213	36,103	24·33	33·83
Ditto ..	52	1 167,909	778,335	„	98,810	389,574	33·35	25·36
Lisburne Mines	6	173,257	110,394	1-10	16,110	62,863	36·28	25·62
East Crinnis	11	352,155	254,442	„	33,000	97,713	27·74	33·75
Carn Brea	17	1,039,312	790,562	1-24	45,406	248,750	23·93	18·25
South Tolgus	3	38,217	22,817	1-15	2,548	15,400	40·29	16·54

"Mean rate of profit on receipts .... 26·6 per cent.
" Ditto dues on profit .... 22·0 ditio."

PHILLIPS & DARLINGTON, *Records of Mining and Metallurgy*, p. 253.

(*d.*) At the *South Cliff* mine (*Table XIII.*), a deposit of (*drift*) boulders, shingle, gravel, and sand, of more than fifty feet in thickness, overlies the rocks;* which—like those of the *Cliff* mine immediately north, —consist of alternating and somewhat ill-defined bands of granular and amygdaloidal trap; dipping—as they also dip—25°–30° towards the north.† But, inasmuch as the boundary between the mines is a vertical one, the upper parts of certain beds are in one mine, and the lower in another.

The only *lode*—of which the adjoining portion is wrought in the *Cliff* mine—still bears 21° W. of N.—E. of S.; dips 75°–85° E.; ‡ and—varying from about twenty inches to three feet and a half—averages nearly two feet, in width.

Calcareous-spar, quartz, and chlorite are abundant; and prehnite is a large—sometimes indeed it becomes the largest—ingredient; but Laumonite, zeolite, labra-

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In the *Lisburne lead-mines* (Cardiganshire) the produce, expenditure, and profits during 1857,—8,—9, were

	AMOUNTS.		
	Expenditure.		
Produce.	Working-costs.	Royalties (*Dues*).	Profit
£102,007	£67,301	£9,816	£24,890
	PROPORTIONS.		
1·	0·6598	0·0962	0·2440

MOISSENET, *Annales des Mines*, 6me Série, IX. p. 122.

* "A shaft was sunk through from 8 to 12 feet of sand, and then through quicksand, until the stratum of *hard-pan* was struck lying directly on the rock, which, itself, was 52 feet from the surface."

WHITNEY, *Metallic Wealth of the United States*, p. 280.

"Les premiers travaux ont eu traversé les 18 mètres (59·3 feet) d'alluvions qui couvrent la valleé."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 315.

"Many loose masses of native copper, some of which contained silver, and were of large size, were picked up."

WHITNEY, *Metallic Wealth of the United States*, p. 249.

† *Ante*, p.422. ‡ *Ibid*, 423.

dorite, hornblende, and epidote are of merely local occurrence.* Large, rough, lenticular bodies of trap, here and there, divide the *lode;* † and—especially where the adjoining *(Country)* beds are granular,—smaller masses of kindred rocks, cemented by, and impregnated with, the other vein-stones, give it a brecciated character.‡ Both the included masses and the contiguous bands of trap, are traversed by short, narrow, veins of crystallized prehnite. Amongst themselves the aggregated prisms generally preserve a tolerable parallelism; though small groups of divergent crystals occur at intervals; for the most part, however, they are disposed at considerable angles to the *(walls)* sides.§ Minute wedge-shaped bits of trap, and—in and near the longitudinal joints—granules of copper,

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* *Ante*, pp. 423—4.

† "Vers le nord, le filon est divisé en deux veines qui reunissent vers le milieu de la partie exploreé, en présentant un renflement extrêmement riche."
RIVOT, *Annales des Mines*, 5me Série, VII. p. 315.

‡ "Many of the veins have a more or less brecciated character; that is, they appear to be made up in a considerable degree of fragments of the adjoining rocks, cemented by the same veinstone as occurs in other veins."
WHITNEY, *Metallic Wealth of the United States*, p. 259.

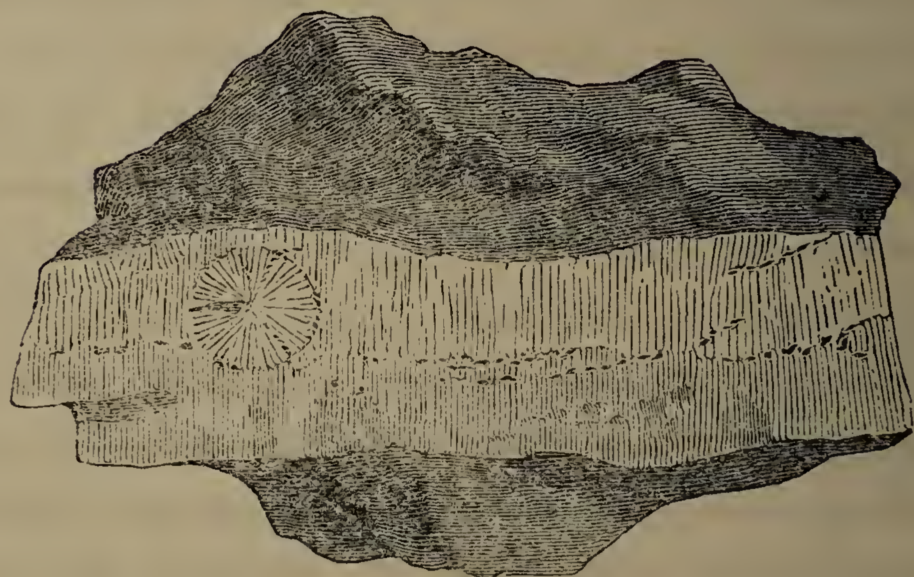
"Dans le trapp compacte, grenu, amygdaloïde, la gangue est formeé de calcaire, de quartz, de feldspath, de chlorite, et des fragments et débris des roches encaissantes."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 264.

§ "The quartz in the cross-courses is very peculiar in its crystalline structure, having a fibrous, striated, or radiated appearance, with the axes of the crystals, when not much radiated, nearly at right angles to the direction of the sides of the veins. * * * The *cross-course spar* usually shows divisions or joints at right angles, and consequently parallel to the sides of the veins, as represented by *fig.* 18, Plate VI."
FOX, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 89.

De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, pp. 339—42. Phillips, *Cabinet Cyclopædia*, GEOLOGY, II. p. 132. Henwood, *Cornwall Geol. Trans.*, V. p. 261.

are—so to speak—entangled in the crystals of prehnite.*

Fig 27. THE SOUTH CLIFF MINE.
A vein of prehnite between walls *of trap.*



(Scale—one-half.)

The small dark triangle, within the group of radiating crystals, represents a minute wedge of trap.

Other spots denote grains of native-copper.

No other part of the district has afforded, at similar depths, so many large masses of copper as the upper *levels* of this mine; † the heaviest occurring in those

* "The veinstone of this mine, near the surface, furnished beautiful specimens of prehnite with crystallized copper. An interesting specimen of the former mineral in radiated nodules in perfectly pure metallic copper (*Fig.* 23) is well worthy of notice, as throwing light on the origin of the metal in the veins."

Whitney, *Metallic Wealth of the United States*, p. 281.

† In February, 1854, "the whole amount of ground opened in driving was 715 feet; cross-cutting, 76 feet; sinking in rock 438 feet; stoping 126 fathoms. From these workings the extraordinary amount of 506,000 lbs. (2258·9 tons *Av.*) of stuff, yielding $67\frac{1}{4}$ per cent. of copper had been taken.

"The largest mass [until then] observed on Lake Superior, was thrown down in this mine on 4th July, 1853; it was about 40 feet long, 20 high, and supposed to average 2 in thickness. Its weight was estimated at from 150 to 200 tons."

Ibid, p. 280.

"Les masses de cuivre sont nombreuses et de grandes dimensions. J'ai vu, en place dans la mine, un gros block déjà dégagé sur environ 30 mètres (16·4 fathoms) en hauteur et 7 à 9 mètres (3·8 to 4·9 fathoms) en direction; son épaisseur, très-variable, atteint 2 mètres (6·5 feet) en plussiers points."

Rivot, *Annales des Mines*, 5me Série, vii. p. 315.

rich *shoots* of vein-stone which—situate on the boundary—belong to the *South Cliff* at and near the surface, but to the *Cliff* at greater depths.

ONTONAGON.

(*e.*) The *Toltec* mine—some twelve or thirteen miles south-east of the harbour *(mouth)* of Ontonagon—is opened in alternating beds of granular and amygdaloidal trap; composed mostly of hornblende and labradorite, mixed often with either epidote or chlorite, and sometimes with both.

The principal *lode*—maintaining much the same *strike* as the adjoining trap-rocks, but more highly inclined than they,—bears slightly N. of E.—S. of W.; dips 55°—65° N.; and varies in width, from a few inches in some, to several feet in other, places. Its chief ingredients are quartz and calcareous-spar; but prehnite is not uncommon, and chlorite occurs at intervals. Angular blocks of trap, often imbedded in, and sometimes transfused with, the other constituents, give—when small—a brecciated character to the *lode:* but—when large— they, so to speak, divide it into *branches.* Native-copper is irregularly sprinkled through all—save the crystalline and trappean—parts of it; but rather in (*Stamp-work*) grains and (*Barrel-work*) small bodies, than in heavy masses.*

" * The character of the lode varies very much in different parts of the mine. At [one spot] it dips 64°, and is about 3 inches wide; at [another], it has an inclination of 56°, and is 20 inches wide, and well filled with copper, a mass of a ton in weight has been found here. At other points it is from 2 to 3 feet wide, and very variable in richness. * * * The gangue of the vein is almost ex-

(*f*.) The *Fire-Steel lode* bears 10°—20° E. of N.—W. of S.; inclines 65°–80° W.; ranges from six inches to three feet in breadth; and consists, for the most part, of calcareous-spar, quartz, prehnite, epidote, and chlorite, irregularly charged with particles and small *nuggets* of copper. Its western side is bounded by a smooth *(hanging-wall)* face of fine-grained, crystalline trap; towards the *(foot-wall)* east, on the contrary, it passes gradually into an amygdaloidal rock, in which the joints are frequently lined with copper.

(*g*.) In the *Indiana location* trial has been made of three *lodes*, which traverse the fine-grained trap-rock from N.E. to S.W.; dip 40°-50° N.W.; and vary, from about three inches to as many feet, in breadth at different parts of their range. Trap, in various states of disintegration, is commonly the largest, and sometimes the only, constituent; though grains, small bodies, and

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clusively quartz, often well crystallized, and occasionally associated with fine specimens of prehnite."

Whitney, *Metallic Wealth of the United States*, p. 291.

"On a formé deux puits principaux et trois puits secondaires dans un filon très-irrégulier, dirigé N. 60° E., et plongeant vers le nord sous un angle de 60° environ. * * * La puissance du filon est extrêmement variable, de 0·m06 à 2 mètres (2·3 inches to 6·5 feet) et plus; des veines secondaires ont été constateés en plusieurs points. * * * Dans les étranglements, le filon est très-quartzeux; dans les renflements, il est rempli par du quartz, de la chlorite, du calcaire spathique, da l'epidote verte, de la matière rouge et des fragments du trapp encaissant, formant des brèches à grandes parties. On a constaté des veinules de laumonite, mais je n'ai vu nulle part ce minéral en veines un peu puissantes. Les renflements présentent souvent des géodes en partie remplies par de l'argile rouge et tapiseés de cristaux de quartz. * * * Dans les travaux actuels, on a trouvé quelques petites masses de cuivre et ce métal disséminé en grains dans la gangue; la matière à bocarder paraît tenir de 2½ à 5 p. 100 de cuivre dans les parties riches."

Rivot, *Annales des Mines*, 5me Série, vii. p. 321.

short thin veins, of quartz, calcareous-spar, epidote, prehnite, Laumonite, and chlorite, either mixed or separate, occur at intervals. Granules, masses, and reticulated threads of copper are imbedded in all the earthy ingredients, but least frequently in the trap.

Many ancient mine-works and tools * have been, from time to time, discovered in the neighbourhood.

(*h.*) The *What Cheer* mine has been opened on two *lodes*,

one bearing	35°–40° E. of N.—W. of S.;	& dipping 45°–56°	N.W.;	width unknown;
the other „	5°–12° „ „	„ 50°	W.;	„ .

Both are, in great measure, composed of coarse-grained trap; but they also contain Laumonite, calcareous-spar, epidote, quartz, prehnite, and chlorite, as well as jaspery and earthy red iron-ore. Particles and *nuggets* of metal, thinly invested with the green carbonate of copper, are sparingly scattered through the vein-stone.

(*i.*) The *Douglas Houghton* or *Henwood* mines † (*Table XV.*; *Fig.* 28, 29.) had reached a depth of more than seventy fathoms in 1856, and they are but little deeper now (1866).

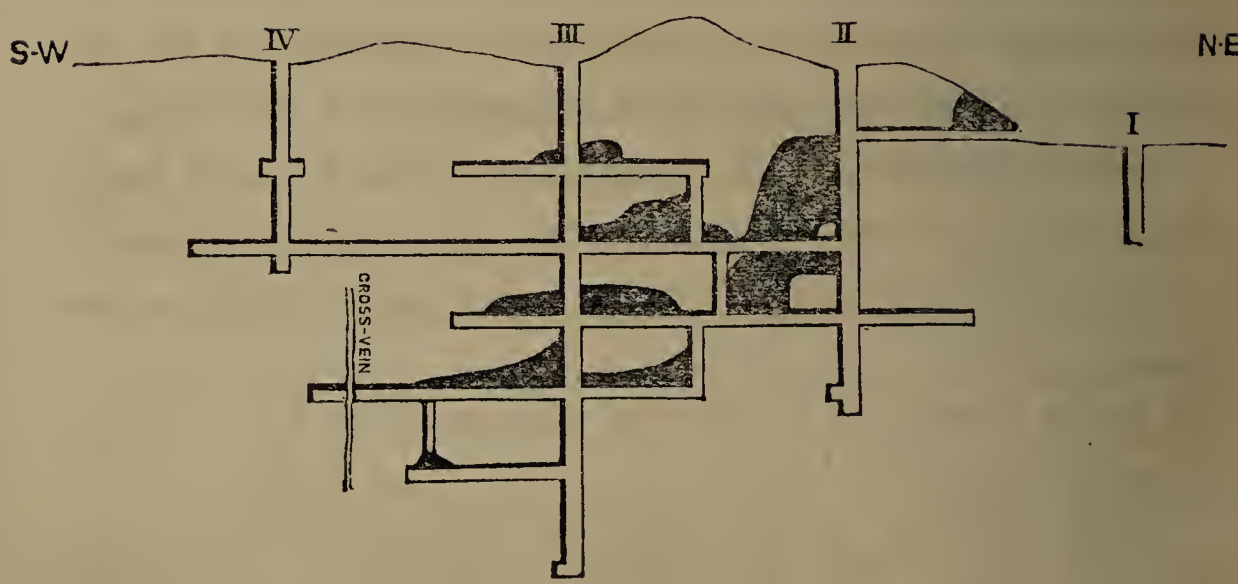
"Masses of ice which had accumulated, at depths of 16·6 and 23·3 fathoms in the mine, during the winter of 1855—6, remained unmelted on the 11th of July following.

* *Ante*, pp. 412—19.

† " The mining operations of this Company have been mostly confined to the north-western corner of Section 22, [Range 37, Township 51, where] low ridges of trap run a little to the east of north and present a steep face on the south eastern side, * * * The trap, which is a dark compact variety, occasionally amygdaloidal in its structure, is divided at intervals of 3 or 4 feet, though irregularly, by seams, which are filled principally with quartz and calcareous spar in very varying thicknesses. * * * When exposed on its mural face, it

Fig. 28. THE DOUGLASS HOUGHTON, OR HENWOOD, MINES, ONTONAGON—MICHIGAN.

Longitudinal section.



Scale 40 fathoms to the inch.

The rocks generally consist of hornblende and labradorite; but chlorite is also a frequent, and epidote is an occasional, ingredient.* Isolated masses and short narrow veins of quartz,—mixed sometimes with calcareous matter, but perhaps as commonly with one

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appears to be divided by a number of seams which follow the general direction of the ridge; and, of course, have mostly a rather east and westerly direction. These are rarely continuous for any great length, yet they may in some instances be traced for a considerable distance. It is impossible, however, to decide on the identity of any two portions of one of these seams, unless the rock is exposed continuously along the whole course of them. [Their dip] is invariably with that of the rock itself—generally at an angle of about 45°. At many points of their course they are accompanied by native copper, which sometimes occurs in very large masses."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, III. p. 743.

* "The rock is a compact chlorite trap."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, pp. 142—50.

"The rock adjacent [to the vein] contains a large amount of epidote."

Whitney, *Metallic Wealth of the United States*, p. 289.

or other of the surrounding substances,—occur at intervals. Within short distances of the *lode* particles and flakes of copper are scattered thinly and irregularly through them all. The structure is mostly coarse and granular; by degrees, however, it becomes fine-grained and crystalline in some, but amygdaloidal in other, places. The entire *(Country)* formation is disposed in somewhat ill-developed beds; which are intersected, at about right-angles, by well-marked joints.

From the *lode* to the neighbouring *(Country)* rocks gradual transitions sometimes take place; but nearly parallel joints frequently form smooth divisions between them.*

The principal *lode* † bears about N.E.—S.W.; and

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* Henwood, *Cornwall Geol. Trans.*, v. p. 181.

† "The vein * * * is about three feet in width, running nearly north and south, conforming to the general direction of the ridge at this place, and dipping west 60°. They have driven a level about 25 feet along its course, and a considerable quantity of copper has been obtained. The vein-stone removed was rich in disseminated and string copper, and will yield from 8 to 12 per cent. of metal. Quartz, * * * forms the principal portion of the matrix, which is traversed by numerous seams of chlorite. The vein is well defined, and affords indications of proving highly valuable."—Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 142.

"The vein, at the surface, appeared between two and three feet wide, with a quartzose veinstone, and was quite well filled with copper. At that point, it had two perfectly defined walls, separated from the rock by selvages of argillaceous matter, and a gangue distinct from the rock. In the workings of the mine, however, it has not so much regularity as would be desirable: in some places it is two feet in width, and well charged with copper; and in others it becomes entirely lost, and can with difficulty be traced. There is a break or fault intersecting the vein vertically, * * * and displacing it to the amount of 14 feet. Two slides have also been found to traverse the rocks, and have shifted and deranged the vein along their course. * * * About 5 tons of barrel-work and mass copper were shipped in 1853, and 20 barrels of stamp and barrel-work, and four masses, amounting to 25 tons in all, were ready for shipment in February, 1864."—Whitney, *Metallic Wealth of the United States*, p. 290.

is represented in various places by either slight traces of vein-stone or the mere contact of *(walls)* faces of trap-rock, yet often attains a width of at least three feet; its average dimensions, however, do not exceed fourteen inches. The narrower parts—peculiar to the fine-grained and crystalline trap *(Country)* alone—are usually composed of Laumonite or chlorite, but now and then they contain copper. The wider portions—natural to the coarse, granular, and amygdaloidal rocks only—abound in quartz; largely, but unequally, mixed with calcareous-spar, as well as with smaller proportions of epidote, chlorite, hornblende, and, perhaps, a few other minerals. Isolated blocks of trap occur here and there. All these enclose copper,* in grains and rough shapeless nuggets of a few pounds each; but the siliceo-calcareous matrix only yields also masses of many hundred-weight. The richer portions are separated, by comparatively worthless vein-stones, into two distinct *shoots;* both which dip endlong towards the south-west. Undulating joints—not always quite parallel to the *(walls)* sides in direction and dip—divide certain parts of the *lode* into *(combs)* slices or subordinate veins; which—at times enveloping lenticular bodies of trap—are commonly characterized by diversities either of composition or of structure.

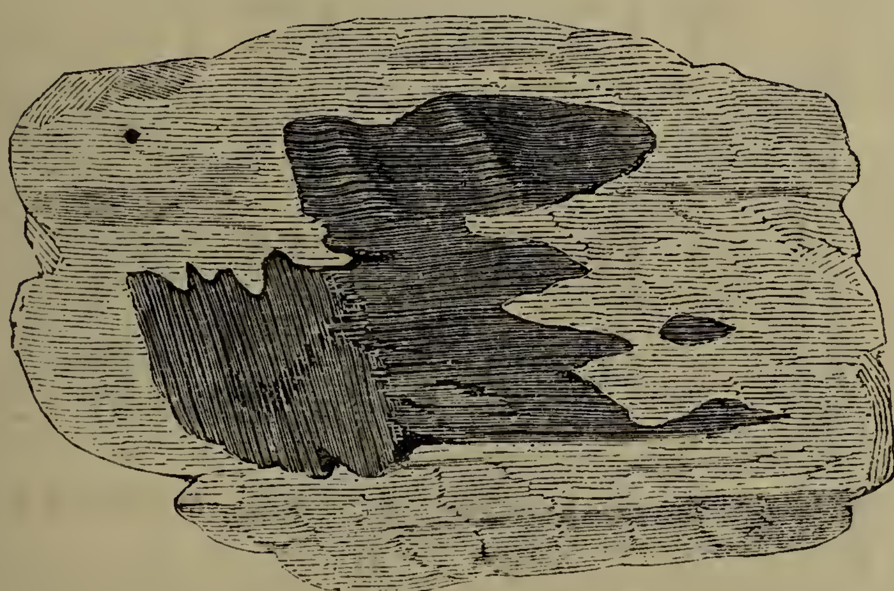
* "A mass of copper recently taken from the back of the fifth level weighed 1000 to 1200 lbs. * * * A piece lately obtained above the fourth level weighted above 1500 lbs. * * *

"Over the back of the third level the stamp-work now being removed is of a higher per centage than the average of stamp-veins, say 2½ to 3 per cent."
Lake Superior Miner (24th March, 1866) xi. p. 224.

Such joints are occasionally filled either with disintegrated *vein-stuff* and earthy red iron-ore, or with thin sheets of copper; of which the glossy faces are sometimes deeply grooved.* On their opposite sides, however, they are now and then fluted in different directions; and even within short distances, on the same sides, the striæ are frequently curved, crooked, interrupted, and divergent.

Fig. 29. DOUGLASS HOUGHTON, or HENWOOD, MINES.

Grooved surface of vein-stone and copper.



Natural size.

Some of the quartz contains cavities lined with crystals; and much—like that of various gold-mines in Brazil †—abounds in cracks, crevices, and flaws; in such instances copper is scarce.‡

The following columns—compiled from accounts kept at the mines—show the quantities of *vein-stone*

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 173,—81,—2, *Tables XVIII., XCV.; Ante*, pp. 13, 90, 433.

† *Ante*, pp. 181—2.

‡ Henwood, *Cornwall Geol. Trans.*, v. p. 206.

extracted from different parts of the mines, and the weights of (crude) copper separated from it, during 1854, 1855, and 1856.*

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* The *National* Mine has been worked in the same district (Whitney, *Metallic Wealth of the United States*, p. 297. *Ante*, p. 414), with the undermentioned results.

Date	Number of Miners	*Lode.* Square fathoms extracted from: Shafts and *winzes*	*Levels*	*Stopes*	Totals	*Masses.* Numbers	*Masses.* Weight tons (*Av.*)	*Barrel-work* tons (*Av.*)	*Stamp-work.* tons (*Av.*)	Totals tons (*Av.*)	Per sq. fm. of *lode* lbs.	Per cubic fm. of *lode* lbs.
1863												
Nov.	118	7·2	10·1	207·3	224·6	17	18·70	5·91	7·19	31·80	317	The *lode* averaged about three feet in width.
Dec. ..	114	6·3	22·9	215·0	244·2	28	18·87	6·68	7·74	33·29	305	
1864												
Jan.	124	2·8	46·8	273·8	323·4	34	11·97	12·01	7·71	31·69	219	
Feb. ..	111	3·3	49·2	228·3	280·8	33	15·29	8·69	6·88	30·86	246	
March ..	100	7·4	44·1	186·4	237·9	28	13.42	10·06	13·56	37·04	349	
April	108	19·5	40·8	176·3	236·6	30	11·25	7·49	15·08	33·82	321	
May ..	111	2·6	40·9	249·6	293·1	43	21·41	7·27	9·74	38·42	293	
June	92	3·4	31·7	206·7	241·8	32	12·15	10·97	15·33	38·45	356	
July ..	86	3·5	18·5	218·8	240·8	22	20·77	7·04	12·	39·81	370	
Aug.	112	—	34·0	308·0	342·0	39	19·28	11·37	14·66	45·31	297	
Sept. ..	105	8·6	13·3	279·9	301·8	41	18·04	13·15	13·69	44·88	333	
Oct.	118	8·8	36·7	294·1	339·6	38	12·35	15·58	16·99	44·92	296	
Nov. ..	129	2·8	23·5	308·3	334·6	28	10·75	16·24	15·62	42·61	285	
Dec.	130	1·4	24·6	370·8	396·8	42	23·16	9·21	2·20	34·57	147	
1865												
Jan. ..	121	—	36·2	293·4	329·6	30	25·41	10·75	—	36·16	249	
Feb.	121	4·5	35·3	290·9	330·7	25	19·89	10·18	12·36	42·43	288	
March ..	128	5·0	31·3	341·0	377·3	39	23·03	12·65	18·33	54·01	321	
April	122	5·3	20·1	272·9	298·3	33	19·19	11·68	15·18	46·05	346	
May ..	107	8·3	7·0	296·6	311·9	28	19·26	8·75	17·04	45·05	324	
June	116	8·8	6·1	316·4	331·3	28	19·87	10·11	8·96	38·94	263	
Totals ..	—	109·5	573·1	5,334·5	6,017·1	638	354·06	205·79	230·26	790·11	—	—
Means ..	114	—	—	—	—	—	0·555	—	—	—	294	588
Proportions .	—	—	—	—	—	—	0·448	0·260	0·292	1·0	—	—

Years	*Lode*, Square fathoms extracted: from shafts and *winzes*	from *levels* (galleries)	from *stopes*	Totals	Crude copper obtained: Total quantity tons (*Avoir.*)	Per sq. fm. of *lode* lbs.	Per cubic fm. of *lode* lbs.
1854...	40·0	59·6	307·6	407·2	25·22	139	738
5...	27·0	75·0	285·6	387·6	22·70	131	695
6...	33·8	50·5	156·2	240·5	10·34	97	515
Totals ...	100·8	185·1	749·4	1,035·3	58·26	—	—
Means ...	—	—	—	—	—	126	669

During this period, therefore, each square fathom of the *lode* yielded lbs. 294 of crude copper;
and as the *lode* was about three feet wide, „ cubic „ „ 588 „ .
The *Masses*—ranging from a few hundred-weight to eight tons, and averaging (0·555 ton) 1,243 lbs. each .... —formed 0·448 of the entire produce;
Barrel-work.............................. „ 0·260 „ ;
Stamp-work.............................. „ 0·292 „ .

From the 1st of November, 1863, to the 31st of October, 1864, 6,330 *Avoir.* (7,090 *United States*) tons of *vein-stone* yielded at the *Stamps* 140·57 tons *Avoir* —each ton thus affording 49·74 lbs.—(0·022206 the weight) of crude metal.

Each *stamp-head* crushed on an average 2,964 lbs. of *vein-stone* in twenty-four (working) hours. (*Ante*, Tables *VII.* column 14, *IX.* Note *m*; p. 426, Note).

The miners—whose numbers varied from 86 to 130 and averaged 114—
broke—one with another—52·8 square fathoms of *lode*, which yielded 6·93 tons (*Av.*) a year each;
and earned— „ — .... £11 : 0 : 4 per month „ .
The labourers ranged from 48 to 50, and received on an average £9 : 13 : 1 „ „ .

Chynoweth (Report of the National Mining Company), *Lake Superior Miner*, xi. (7th October, 1865), pp. 32—4.

90·35 tons *(Avoir)* of crude metal from the *National* Mine, yielded—from the 1st of May to the 12th of July, 1866,
66·39 „ „ (0·7348) its weight) of fine copper.

Pontalba, *Detroit Free Press*, xxx. (28th July, 1866) p. 1.

A comparison between the proportions of copper in the *lodes* near Lake Superior, and of tin-ore in those of Cornwall and Devon, can scarcely be uninteresting.

In 1856 the entire produce—except from *masses*

Rocks		Mines	Tin-ore, lbs. of per ton (*Av.*) of *vein-stone* Richest	Poorest	Average	Proportions Richest	Poorest	Average
Granite.		*Birch Tor* (Devon)	1120	—	28	0·5000	—	0·0125a
		Condurrow	650	20	28	0·3000	0·0089	0·0125b
		Wendron Consols ...	—	—	28	—	—	0·0125c
		Boscaswell, ... 1865..	—	—	34·2	—	—	0·0153d
		Botallack	—	—	40	—	—	0·0179e
		Balleswidden	1120	12	45	0·5000	0·0054	0·0201f
		Saint Ives Consols	1344	7	45	0·6000	0·0331	0·0201g
		Great Work	—	—	56	—	—	0·0250h
		Wheal Basset & Grylls, 1865..	—	—	60	—	—	0·0268i
		Trelyon Consols	—	—	68	—	—	0·0304j
		Boscean	—	—	68·3	—	—	0·0305 } d
		Carnyorth	—	—	69·5	—	—	0·0310 } d
		Providence	700	14	70	0·3120	0·0063	0·0312k
		Ding Dong	1176	15	70	0·5250	0·0067	0·0312b
		Wheal Mary ..	—	—	101·5	—	—	0·0450l
Slate & Granite slate, and *elvan.*		*Carn Brea*	—	—	36	—	—	0·0161m
		Cook's-kitchen 1865..	—	—	37	—	—	0.0165 } n
		Cook's-kitchen 1866..	—	—	40	—	—	0·0179 } n
		Dolcoath A 1863..	112	22	55 }	—	—	0·0245 } n
					60 }			0·0268 } n
		Dolcoath A 1865..	—	—	44	0·0500	0·0093	0·0196 } n
		Tincroft A	—	—	50·4	—	—	0·0225o
	elvan.	*North Roskear* A	61	9·8	23·8	0·0272	0·0044	0·0106p
		Poldice (St. Day United) ..	192	13	30	0·0157	0·0058	0·3134q
Slate.		*Lanivet* A 1863,-4,-5..	—	—	2·5	—	—	0·0011 } r
		Mulberry Hill	—	—	5·25	—	—	0·0023 } r
		North Wheal Robert (Devon)	—	—	8	—	—	0·0035a
		Polberrow A	15·2	7·6	9·84	0·0068	0·0034	0·0044s
		Drake Walls	—	—	11	—	—	0·0049t
		Furze Hill Wood (Devon) ..	—	—	20	—	—	0·0089a
		Prosper United	160	9	26	0·0714	0·0040	0·0116u
		Wheal Busy	—	14	47	—	0·3063	0·0210v
		Wheal Vor	204	88	144	0·0911	0·0375	0·0643w
		Par Consols	560	11	—	0·2500	0·0049	— } x
		Cuddra ..	784	15	—	0·3500	0·0067	— } x

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A "The quantity of tin-ore is small compared with the valueless matter with which it is mixed This will be evident from the following statement of the quantities of tin-ore contained in the mass, as it is brought to the surface, from the mines named:—

which weighed together 1,032 lbs. (0·46 ton *Av.*)—consisted of *Stamp** and *Barrel work.*†

The shafts, *winzes,* and *levels* comprise the entire width of *the lode,* and frequently also some of the *(Country)* rock adjoining it; the *stopes*—except on rare occasions—are opened on the *lode* alone.

The average cost of opening a square fathom in each was as follows:—

Years.	Shafts & *winzes.*	*Levels.*	*Stopes.*
1854 ..	£16 6 11	£12 2 6	£5 7 11
5 ..	18 11 3	11 15 11	5 2 1
6 ..	19 16 0	12 5 10	4 17 3
Means..	£18 2 0	£12 0 0	5 3 6

It seems, therefore, that as the proportion of copper declined, the cost of *stoping* also diminished; but the expense of opening shafts, *winzes,* and *levels,* at the same time, increased.

These columns relate to tin-ore only; whereas *Table XIV.* comprehends the whole produce of the mines. No comparison can therefore be made between them.

* "At the *Henwood* mines the new steam-stamps—four batteries, 16 heads—are of the heaviest pattern, 1050 lbs. to the head."

Lake Superior Miner, XI. (24th March, 1866), p. 224.

† "4·32 tons *(Avoir.)* of crude metal from the *Henwood* mines yielded 3·01 tons (0·6966 its weight) of fine copper."

PONTALBA, *Detroit Free Press,* XXX. (28th July, 1866) p. 1.

" Huel Kitty, St. Agnes	84 lbs.	of oxide of tin in every ton.	
Dolcoath, Camborne	56 ,,	,,	.
Tincroft, ,, ...	35 ,,	,,	.
North Roskear, ,, ...	25 ,,	,,	.
Huel Uny ,, ...	23 ,,	,,	.
East Carn Brea, ,, ...	18 ,,	,,	.
Polberro Consols, St. Agnes	14 ,,	,,	.
Huel Coates, ,, ...	6 ,,	,,	.
Lanivet	4 ,,	,,	."

Quarterly Journal of Science, III. (January, 1866) p. 108.

Some thirty-six fathoms from the surface a joint,*—ranging nearly S.E.—N.W.— intersects one of the narrowest and poorest parts of the *lode,* which it *(heaves)* displaces about eight feet (L.—R.A.) towards the *left-hand.*† On opposite sides of the joint, however, both the width and general characters of the *lode* are materially different.

At a depth of forty-eight fathoms, the *lode*—maintaining an uninterrupted course from the N.E.—abuts on a nearly vertical *cross-vein* of disintegrated ferruginous trap, about six inches wide, and thenceforth its normal direction, towards the S.W., is denoted by a few small, unconnected, masses of vein-stone only; and *cross- (cuts) drifts* on both sides have failed to detect parallel *branches.*

The *Conglomerate* stands S.E. of the *Principal lode,* takes much the same direction, and dips the same way; at so different an angle, however, that they are as much as fourteen fathoms apart at the surface, but no more than five feet at the seventy-one-fathom *level.* The shallower portions, which are about eighteen inches wide, consist generally of trap, in various stages of disintegration; enclosing, however, many angular and spheroidal bodies of much the same composition, but of harder texture, and rounded stones of quartz-rock containing small crystals of oxydulated iron; calcareo-siliceous matter occurs, here and there, in

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* Henwood, *Cornwall, Geol Trans.*, v. pp. 25, 327. *Ante, Table XV.*

† "In the Ontonagon District the *heaves* are commonly towards the left-hand."
Emerson, *Lake Superior Miner*, II. (30th May, 1857), p. 2.

shapeless lumps, and short, thin veins, but frequently also it pervades the trap. At seventy-one fathoms deep it is only half as wide, yet consists still of disintegrated trappean matter, including reniform masses of trap and of quartz-rock near the sides, but traversed by narrow calcareo-siliceous veins towards the middle. Grains, flakes, and slender threads of copper are numerous in the wider parts; and particles may be readily extracted from the narrower, by crushing and washing the matrix.

But operations on this formation have been induced —less by the proportions of metal it has yielded than— by an expectation that the *Principal lode* and the *Conglomerate* would afford at their contact, similar results to those which take place where productive *lodes* fall in with the cupriferous conglomerates of neighbouring mines.* Such contact, however, can

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* "At the *Minnesota* mine * * * the ranges of trap run in a N.E. & S.W. direction * * * and are flanked by sandstone and conglomerate, dipping northerly, besides containing intercalated beds of these detrital rocks."

FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 133.

The extent, appearance, and produce of the ancient works have been frequently and fully described."—*Ante*, pp. 412,—13,—14,—16.

"In 1849 * * * a drift was extended eighteen feet in length and at thirty-eight feet below the surface, on (the *North lode)* a vein about eight feet wide, almost entirely filled in with sheets of native copper. Shoots branch off from the main mass, occupying the fissures, so as to interpose a brazen barrier to further driving."—FOSTER & WHITNEY, *Report on the Geology of the Lake Superior Land District*, I. p. 133.

"In January, 1854, the whole number of fathoms of vein removed amounted to 4,152 fathoms; and the yield of copper was, approximately, 582 lbs. per fathom."—WHITNEY, *Metallic Wealth of the United States*, p. 295.

"En janvier 1854, on avait enlevé dans la mine environ 16,500 mètres carrés (5030·5 square fathoms) de surface lateralé, sur une épaisseur variable avec la

result only at a greater depth than the works have yet attained.

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puissance du filon, et retiré 72 kilogrammes (158·7 lbs. *Avoir.)* de cuivre par mètre."—RIVOT, *Annales des Mines*, 5me Série, VII. p. 318.

"During the summer of 1852 a large quantity of copper was taken from (the *South lode)* a vein lying between a belt of conglomerate and the trap; * * * and on driving by the side of the conglomerate, large masses of copper were found. In 1853 there was a lode, in some places 5 feet wide, and filled for a distance of 40 feet with an almost continuous mass of copper."

WHITNEY, *Metallic Wealth of the United States*, p. 296.

"In January 1857 at a part of the 20 fathom level where a mass of copper from 12 to 18 inches thick had been obtained from the *foot-wall* of the *South lode*, strings of copper were found to branch from it into the conglomerate. These were followed, and led immediately to very large masses. One of these—so thick that it could not be handled in the mine until it had been divided longitudinally—presented, when cut by the chisel, a thickness of three feet and nine inches."

Below the *adit-level* in the south-western part of the mine, however, similar threads of copper were at the same time traced from a productive part of the *lode*, through the regular *foot-wall*, into the conglomerate beneath; where they united with a series of rich "masses going up and down, with a north-easterly inclination for 70 or 80 feet, and still continuous above and below. At a convenient point the rock behind (beneath) the largest body of copper was removed by successive *sand-blasts (Ante*, p. 427, Note *a)*; but charges which were gradually increased from 125 to 550 lbs. failed to dislodge it. At length 30 *kegs*, or 750 lbs. of gunpowder, were securely *tamped* beneath it and fired. When the smoke and dust had disappeared, a mass of about the following dimensions—

	Length	Breadth (height).	Thickness.
Extreme	46· feet.	18·5 feet.	9· feet.
Average	—	12·5 „	3·5 „

was found to have been lifted from its place, without flexure or crack.

"These dimensions give it a cubic content of nearly 2,000 feet, and a weight of about 500 tons."

As many men as the size of the mass and the width of the works permitted (on one occasion as many as 42) were employed for several months in cutting it into pieces of manageable size. "In most of the longest and deepest cuts the copper was as bright as a new penny; but in some places large pieces of rock were found enclosed.

"This, we respectfully submit, is the largest mass of metal of any kind ever yet exhibited in a single piece upon this planet."

EMERSON, *Lake Superior Miner*, II. (28th February;—21st March;—4th April;—6th June;—4th July;—15th August; 1857). Abridged.

"The largest mass of native copper ever discovered was taken out of the *Minnesota* mine in 1857—8.

When the surface is covered with frozen snow,* the influx of water rarely exceeds a thousand gallons (163·2 cubic feet) per day; but when a thaw sets in, and during rain,† the quantity is often trebled. In-

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Its average	length	was about	36 feet;—
,, ,,	width (height)	,, ...	14 ,, ;
,, ,,	thickness	,, ...	$3\frac{1}{4}$,, ;
,, greatest	,,	,, ...	$7\frac{1}{2}$,, ;
,, least	,,	,, ...	1 foot.

Its weight exceeded 400 tons (*Avoir.*); and in dividing it, for convenience of removal, about 15 tons of chips (*Ante*, pp. 427—8) were cut out.

"The mass afforded 85 per cent. of fine copper."

Captain J. T. Brown, Manager of the *Ontonagon* Copper Mine, MSS.

"Many masses occur in the conglomerate north-east of the great mass. There is no one piece as large as the great mass, but the amount of copper exposed in masses of immense size is very much greater than that will yield. Enormous sheets from a foot to several feet in thickness are still going almost horizontally into the conglomerate. Being one above the other, with some regularity of occurrence, they seem to form great steps under the foot-wall of the vein. How far these sheets penetrate the rock can only be ascertained by following them."

Emerson, *Lake Superior Miner*, ii. (4th April, 1857) p. 2.

In the *National*, a neighbouring, mine, the conglomerate likewise affords similar, though smaller, masses of copper. Whitney, *Metallic Wealth of the United States*, p. 297. Emerson, *Lake Superior Miner*, ii. (30th May, 1857) p. 2; *United States Mining Journal*, x. (27th June, 1857) p. 5. Chynoweth, *Lake Superior Miner*, xi. (7th October, 1865) p. 32.

* At Fort Wilkins, on Keweenaw Point, the temperature, observed at 9 a.m., 3 p.m., and 9 p.m., between June, 1844, and May, 1846, ranged from 18°·16 to 72°·03, and averaged 41°·46.

From Nov., 1844, to March, 1845,	(both included)	the mean was below the freezing point	At 3 p.m. the temperature never once exceeded	31°·30
From Nov., 1845, to Feb., 1846,	(,,)		,, ,,	33°·46

Returns of the Surgeon General of the United States Army. Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 43.

"The temperature of the water of Lake Superior during the summer, a fathom or two below the surface, is but a few degrees above the freezing point. In the western portion, the water is colder than in the eastern—the surface flow becoming warmer as it approaches the outlet."—*Ibid*, p. 54.

† "From observations made by the Army Surgeons at Fort Brady—Sault Ste. Marie it was ascertained that the mean annual fall of rain during the years 1837, —8,—9 amounted to 31—89 inches.—*Ibid*, ii. p. 338.

deed, a single long and heavy shower * has sufficed to fill the deepest *(level)* gallery for several days. Neither steam † nor water ‡-power has yet been applied to the drainage; which is still effected with buckets drawn by a horse-*whim*.

A mass of ice, some eighteen inches thick, which had accumulated at the thirty-six-fathom *level*, between the first and second shafts, in the winter of 1855-6, remained unmelted in the following July.§ During

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* "The 6th of July, 1865, forms a memorable epoch, as the date of the greatest flood that ever visited our country. The rain commenced in the after part of the day previous, increasing to torrents before midnight and so continued; the heaviest fall being about three o'clock in the morning. The depth of rain which fell was,—at Ontonagon village.... $4\frac{3}{4}$ inches in 14 hours;
,, Ogima mine .... 9 ,, ,, 12 ,, ;
,, Rockland ,, ... 10 ,, ,, 12 ,, ."

Crozier, *Lake Superior Miner*, x. (8th July, 1865) p. 358.

† Coal brought—by water some seven hundred miles—from Cleveland in Ohio, is found a cheaper fuel for the steam-engines at Keweenaw Point, than wood grown on the spot.

M. W. Kelsey, Esq., Superintendent of the *North American* mine, MSS.

‡ *Ante*, p. 477, Note †.

§ *Ante*, p. 465, Note.

"The *National* mine is opened and mainly worked by adits. * * * The lower, or third, is the present working adit; as the mouths of the other two are closed for the purpose of turning the warm air of the mine through the engine-shaft, to prevent the pump from freezing. A large building has been erected at the mouth of this adit, which affords abundant room for a warming-house, a mineral-house, and in the upper story a changing-house. It is warmed by a large stove which completely disposes of all the ice by which they were formerly troubled, and ventilates the pump-shaft with warm air, so that it is kept from freezing without difficulty in any weather."

Emerson, *Lake Superior Miner*, ii. (21st March, 1857) p. 2.

"Ordinary work in the mines is carried on in winter as in any other season of the year, the greatest trouble arising from the accumulation of ice in the shafts: this has frequently to be cut away, otherwise pumping and hoisting must stop. Special care has to be taken to prevent the water in the pumps from freezing. The *lift* is commonly boxed up, and surrounded with some non-conducting substance. Trap-doors are placed in the *levels;* and with these precautions, and the engine stopping only half-an-hour at a time, in the mine where I was employed,

the warm weather, however, water oozing from above had thawed a shallow channel in its surface.

(*j.*) The *Algonquin* mine, three or four miles north-east of *Douglass Houghton*, has been opened to a depth of fourteen fathoms, in rocks of hornblende, labradorite, and epidote; * which are often coarse-grained, and sometimes amygdaloidal.

The only *lode* examined—bears 45°–50° N. of E.—S. of W.,—dips 40°–45° N.W.,—is from four to eight feet wide,—and consists of disintegrated trap and epidote, often transfused with siliceous and calcareous matter, but sometimes enclosing both masses of quartz

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the water in an eight-inch *plunger-lift* was frozen solid for sixty feet down from the *collar-launder* in one night."

Daniel, *Mining Journal*, xxxvi. (23rd June, 1866) p. 390.

"At Röraas in Norway the lower chambers are so cold, that ice appears everywhere in large masses, or in isicles hanging from the roof, and from the ladders fixed in the shafts; the steps of which are covered by ice, as to become thereby slippery and dangerous."

Clarke, *Travels in Europe, Asia, and Africa*, x. p. 187.

"At Persberg, large masses of ice appeared, covering the sides of the precipices, as we descended further from the surface. Ice is raised in the buckets with the ore and rubble of the mine: it has also accumulated in such quantity in some of the chambers, that there are places where it is fifteen fathoms thick, and no change of temperature above prevents its increase."—*Ibid*, p. 491.

Browne, *Ice-caves of France and Switzerland*, passim.

* "The *Algonquin* Company have examined the surface at several points along a bluff which runs nearly in a N.E. & S.W. direction, the steep side of the ridge facing to the N.W. The trap is tolerably compact, and much mixed with epidote. About half a mile N.E. of the house, copper has been found sparingly intermixed with quartz and epidote. One-fourth of a mile further on, an open cut has been excavated about 35 feet in length and 10 feet deep; its direction is nearly N. 60° E. From this excavation a considerable quantity of metallic copper has been taken, mostly intermixed with quartz and epidote."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, iii. p. 741.

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. pp. 71, 142. Whitney, *Metallic Wealth of the United States*, p. 289,

and crystals of calc-spar. All these—but especially the two last—are irregularly sprinkled with *(Stamp* and *Barrel-work)* particles and small lumps of copper, as well as with much smaller quantities of malachite.

Whether the joints are longitudinal or transverse,—peculiar to the *lode*, or common alike to it and to the *(Country)* rock,—they frequently contain thin sheets, and dendritic plates of copper.

(*k.*) At the *Rockland** mine,—adjoining the *Minnesota*,†—a bed of conglomerate, consisting of globular, spheroidal, and reniform masses, mostly of hornblende and labradorite but now and then of quartz-rock, cemented by trappean and siliceo-calcareous matter,—is separated from the ordinary coarse-grained, and somewhat amygdaloidal, rock,—which forms the surface,—by a *lode*, vein, seam, or bed, bearing 35°—45° N. of E.—S. of W., dipping 45°—55° N.W.,—occasionally as thin as paper, but in some places two feet wide,—composed, generally, of disintegrated trap, chlorite, epidote, quartz, and calcareous spar; but, at intervals, almost entirely of copper. Its outcrop presents a mere *(parting)* joint faced with chlorite; but -rapidly widening—it shortly includes a small (*horse*) mass of trap; and, at the same time, traces of siliceo-calcareous matter appear between it and the *(foot-*

* The *Rockland* mine "adjoins the Minnesota mine on the east. * * * In 1853 a large and rich lode was opened here, which appeared to be identical in course and mineralogical character with the Minnesota vein. The dip of the lode is, near the surface, 48½°, and its whole line of outcrop is marked by numerous ancient excavations."—Whitney, *Metallic Wealth of the United States*, p. 296.

† *Ante*, pp. 459,—473—5.

wall) conglomerate. The trap is gradually replaced by quartz; tinged in different places with chlorite or epidote; and, at unequal distances, implanted with rough crystals of calc-spar. Such ingredients form the matrix most congenial to copper; which occurs—at first thinly sprinkled and in particles;—next in larger grains;—soon in clustered *nuggets;*—shortly in thin ragged plates;—and at length in slabs varying from less than an inch to more than a foot in thickness, and of several fathoms in length and height. These are often made up of many parallel sheets, and sometimes they envelop bodies of vein-stone; but frequently solid masses of metal occupy almost the entire width of the *lode.* Commonly, however, a narrow line of *Stamp-work* rests on the *(foot-wall)* conglomerate.*

In 1856 a mass of copper, some ten fathoms long, three fathoms high, and from one-twentieth of an inch to fourteen inches thick, was discovered above the *adit.* It was cut, as it lay, into pieces of convenient size; which were lowered to the *level* by means of blocks, and drawn to the surface on a tram-way.

* "The undermentioned quantities of crude copper were obtained from the mine in 1856:—

	(*Avoirdupois*)	
January and February	6·54	Tons
March and April	15·49	„
May	13·67	„
June	17·17	„
July	25·87	„
August	27·81	„
September	34·62	„
October	27·26	„
November	19·91	„
December	19·95	„
	208·29	„
of which the *Stamp-work* amounted to (0·2032 its weight)	42·33	„ ."

EMERSON, *Lake Superior Miner,* II. (17th January, 1857) p. 2.

The *lodes* of Keweenaw are characterized by prehnite and various zeolitic minerals; those of Ontonagon by epidote; but, in both, quartz and calcareous-spar are prevalent vein-stones. The proportions and aggregations of crude copper are shown in the following columns.—

Districts and Mines.	Crude copper		Proportions.			
	per square fathom of *lode*. lbs.	per cubic fathom of *lode*. lbs.	Masses.	*Barrel-work.*	*Stamp-work.*	Totals.
KEWEENAW.						
The *Cliff**	1,425	5,700 to 6,840	0·139	0·081	0·780	1·
,, *South Cliff*†	3,048	9,144				
,, *Copper Falls*‡	865	1,400 to 1,700	0·355	0·645	—	1·
ONTONAGON.						
The *National*§	294	588	0·448	0·260	0·292	1·
,, *Mass*‖	970	1,164				
,, *Douglass Houghton* ¶	126	669				

From this it seems that the narrow and highly inclined veins of Keweenaw, which intersect the trap-range in about a meridional direction, and are distinguished by the presence of prehnite and zeolite, contain larger proportions of copper than the larger

* Whitney, *Metallic Wealth of the United States*, p. 227. *Ante*, pp. 434—5.

† Whitney, *Metallic Wealth of the United States*, p. 280. *Ante*, pp. 460—3.

‡ Whitney, *Metallic Wealth of the United States*, pp. 265—6.

§ Chynoweth, (Report of the National Mining Company), *Lake Superior Miner*, XI. (7th October, 1865) pp. 33—4. *Ante*, pp. 470—1, Note.

‖ Chynoweth (Report of the Mass Mining Company), *Lake Superior Miner*, XI. (14th October, 1865) p. 42.

¶ *Ante*, p. 471.

and flatter *lodes* of Ontonagon, which are nearly parallel to the adjoining beds of trap in direction, but are oblique to them in dip; *strike* east and west in some—but rather north-east and south-west in other, places; and abound in epidote everywhere. The examples yet recorded, however, are too few to warrant general conclusions,*

The writer was prevented from visiting several considerable mines, which he had been invited to examine, in the two principal copper districts. The neighbourhood of Portage Lake has become important since his last mission to America.

The thick beds of transported matter which overlie great part of this–still insufficiently explored–region,†

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* "The *Central* mine, about 14 miles east of the *Cliff*, is opened upon a * * * lode consisting of a series of alternations of red laumonite strings, with large lenticular expansions containing copper. The original discovery of this lode was made in an old Indian working, [but] only a small amount of metal has been found immediately below this point in sinking; but further north, below the greenstone, under similar conditions to those observed in the *Cliff mine*, a very rich run of ground has been discovered. There is a good deal of calcspar in the vein, and the finer copper appears rather in sheets than in shots. At the 50-fathom level the largest mass that has yet been discovered on the lake was struck; it measured 50 feet in length, 30 in height, and about 4½ feet in greatest thickness and yielded somewhere over 500 tons of copper."—Bauerman, *Quarterly Journal of the Geological Society*, xxii. (November, 1866) p. 457.

† "The region of the great lakes may be considered as the headquarters of the North American drift. From the mouth of the St. Lawrence to the borders of Lake Superior there is hardly a spot where the drift deposites are lost sight of. There is, however, no place where these formations are more extensive than on the southern shore of Lake Superior; where, they not only constitute the only visible formation for nearly one hundred miles, but they also attain an astonishing thickness, * * * forming in some places cliffs not less than three hundred and

contain, at intervals, considerable quantities—and, in some places, large masses*—of copper. These seem to have been discovered by an earlier race of inhabi-

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sixty feet high. * * * The drift of Lake Superior may be divided into four deposites, which, in ascending order, exhibit the following characteristics:—

1st. "A layer of coarse materials, * * * generally a mixture of loam and fragments of rock of different sizes,—sometimes worn, but more frequently angular. As a leading feature, it is almost exclusively composed of fragments of the rocks in *situ*. * * * The whole mass is nowhere more than thirty feet thick."

"2nd. A layer of clay resting either on the coarse drift, or, where this is wanting, on the rock. * * * It is difficult to determine its average thickness, from the fact that, in many places where it is highly developed, it sinks below the waters of the lake, and in other cases, where its base is visible, its top has been partly washed away. * * * It appears to be a mixture of loam and clay, and its colour is owing to the decomposition of the red-sandstone and trap from which it has been derived. Though the main mass is composed of very finely comminuted substances, and often of an almost impalpable powder, yet many pebbles are interspersed, and even boulders of considerable size, generally rounded and smoothed. Fragments of metallic ores and native copper occur occasionally in it—the latter sometimes weighing several hundred pounds. It was by these that the attention of the early travellers was first attracted to the copper mines of the region. * * *

"3rd. A deposite of sand, gravel, and pebbles, irregularly stratified, * * * not only covers the clay deposite in most of the localities where the latter has been observed, but also extends over many places where this does not reach. * * * Layers of fine sand alternate in every possible way with layers of pebbles,—sometimes by a gradual transition, at other times abruptly. The pebbles themselves are composed of all kinds of stone—some from the immediate neighbourhood, others from places more remote. They are generally rounded and smoothed. The same is the case with boulders imbedded in the mass, of which there are many from five to six feet through. * * * Its greatest thickness we found to be * * * about three hundred feet. * * *

"4th. A considerable number of isolated boulders, scattered over the whole region, form the uppermost portion of the drift deposites. * * * As to their mineralogical composition, there is every variety of rocks to be found, and in many instances they may be traced to their origin at no very great distance."

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. pp. 186—91. (Abridged.)

* "It is well known that, south of Lake Superior, transported masses of native copper are occasionally met with, in the diluvial deposits which are so abundantly spread over the country. * * * The source of these transported masses has, heretofore, been somewhat obscure * * * but without doubt a very considerable of them had their origin from true veins. * * * The

tants than the Indians who now people the country; * —they attracted the attention of practical miners more than ninety years ago; †—and are still—as, perhaps,

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great transported mass of native copper on the Ontonagon river, which contains about four tons of metal, has all the characters of the other loose masses,"

Douglass Houghton, Proceedings of the Association of American Geologists; *Silliman's Journal*, xli. p. 29.

"The copper-rock or boulder, which lies in the yard between the War and Navy Departments in Washington, has an extraordinary history. It was brought from the banks of the river Ontonagon, and has, it is said, been known over two hundred years. The Jesuits who first visited that part of the country, heard of it from the Indian priests, who however refused to conduct the missionaries to the spot where it lay, on account of a superstitious belief that when the white man had seen it the Indians would be destroyed. * * *

"During the visit of General Cass to this region in 1820, he sent a party of men to fetch it. They burnt a large pile of wood over it, with the intention of breaking or divesting it of rock, but its great weight prevented them from getting it away.

"In 1827 Mr. George Johnston visited it; but, as the river was high at the time, it was pretty much covered. He, however, succeeded in raising it on *skids*, and in cutting from it some fifty pounds of specimens. In the summer of 1841 or 1812 Mr. Paul and an educated half-breed named Nicholas Mincleer, built a cabin over it, with the intention to secure possession. After a time, when their claim seemed to be undisputed, it was removed, with great labour to the mouth of the Ontonagon river; where it remained during the greater part of a summer, and was finally sold to Mr. Eldred. It was afterwards claimed by the Agent of the United States,.and was finally removed to the seat of Government. * * * By order of Congress Mr. Eldred was paid the sum of five thousand six hundred and fifty five dollaas (£1,178 : 2 : 6 Stg.) for his services."

Lake Superior Miner, ii. (26th September, 1857) p. 21.

"About [1864] two years since [a mass of copper], which weighed about 18 tons, was found loose on the drift covering the rock in the Mesnard location near Portage Lake."

Bauerman, *Quarterly Journal of the Geological Society*, xxii. (1864) p. 452.

* "Claude Alloüez [who visited Lake Superior in 1666] states that pieces of copper, weighing from ten to twenty pounds are frequently found by the savages."

Jackson, *Report on the Geological and Mineralogical Survey of Lands in Michigan*, iii. p. 377.

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, i. p. 7.

Ante, pp. 412—19.

† "The first actual mining operations within historical times were commenced near the Forks of the Ontonagon, in 1771, by Alexander Henry. Having

they were by the aborigines—sought as guides to their parent *lodes*.* But less generally distributed,—or more correctly speaking—perhaps less frequently met with, than either the *Shodes* † and the *Stream tin-ore* ‡ of Cornwall, or the *(Cascalho)* auriferous detritus § of Brazil, they have themselves—because of their market

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worked without success for a while at this point, searching in the clay bluffs which line that river for masses of native copper, operations were transferred in the next year to the north shore of the Lake; but, as might have been expected under the circumstances, they proved entirely abortive."

Whitney, *Metallic Wealth of the United States*, p. 247,

"On the side of a rivulet, ten leagues to the south of Lake Superior in North America, there is a single lump of native copper, about four tons weight, free from any mixture but a few small black Stones of an Iron nature, and some very fine grains of Crystal. * * * No vein of copper was discovered on the south side of the Lake, near this lump; but some few very small ones on the north side, not worth the pursuit. This I had from two credible Miners of Redruth, who were sent over to make discoveries in consequence of this singular appearance."—Pryce, *Mineralogia Cornubiensis* (published in 1778), p. 61.

* *Ante*, p. 460.

† "Tin is found disseminated on the sides of hills in single stones, which we call *Shodes*, sometimes a furlong or more distant from their *lodes*, and sometimes these loose stones are found together in great numbers * * * which we call a *Stream*.—Borlase, *Natural History of Cornwall*, p. 161.

"In certain situations the *Shodes* are in greater quantities in valleys, than on the tops or sides of hills; but such are smaller, and more easily carried down by water, and formed into strata, which furnish our *Stream-works*. * * * The heaviest stones are nearest to the *lode*, and the lighter are protruded * * even to five miles distance."—Pryce, *Mineralogia Cornubiensis*, p. 125.

‡ Maton, *Observations on the Western Counties*, i. pp. 159—74. Rashleigh, *British Minerals*, ii. p. 25, *Pl. XXI.; Cornwall Geol. Trans.* ii. pp. 281—4. Hawkins, *Ibid*, i. p. 235. Smith, *Geol. Trans.*, o.s., iv. pp. 404—9. Colenso, *Cornwall Geol. Trans.*, iv. pp. 29—39. Carne, *Ibid*, pp. 45—56. Henwood, *Ibid*, pp. 57—69; v. pp. 90*, 110, 129. Winn, *Reports of the Royal Institution of Cornwall*, xxi. *Ante*, pp. 452—3.

§ Mawe, *Travels in Brazil*, p. 268. De Saint-Hilaire, *Voyage dans le district des Diamans et sur le littoral du Brésil*, i. pp. 127, 201. von Eschwege, *Annales des Mines*, viii. p. 409; *Pluto Brasiliensis*, pp. 505—6. Southey, *History of Brazil*, iii. p. 827. Claussen, *Bulletins, de l'Académie, Royale de Bruxelles*, viii. 1re Partie, p. 335. *Ante*, pp. 342—51

value—been in but a single—and that an unsuccessful —instance,* the object of special pursuit.

In 1819 and in 1823 Commissioners were appointed by the Government of the United States to examine the entire territory; † and in 1841 a Report on its metallic products was presented to the Legislature of Michigan by Dr. Douglass Houghton.‡ It was not until the cession of several extensive tracts by certain tribes of Indians in 1843, however, that permission to search for minerals and to work mines was granted by competent authority; § but within three years nearly a thousand concessions were made.||

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* *Ante*, p. 485, Note †.

† Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 13. Whitney, *Metallic Wealth of the United States*, p. 247. Rivot, *Annales des Mines*, 5me Série, VII. pp. 179—81.

‡ "In 1841 Dr. Douglass Houghton, State Geologist, published an account of his observations, in the form of an Annual Report to the Legislature of Michigan, in which the first definite information with regard to the occurrence of native copper, in place, on Lake Superior, was given to the public; which did more than anything else towards awakening an interest in that region, and directing towards it the attention of explorers."

WHITNEY, *Metallic Wealth of the United States*, p. 248.

Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. p. 13. Rivot, *Annales des Mines*, 5me Série, VII. p. 180.

§ Foster & Whitney, *Report on the Geology of the Lake Superior Land District*, I. pp. 14—15. Whitney, *Metallic Wealth of the United States*, p. 248.

|| "The whole number of permits granted under the authority of the Department of War amounted to about one thousand—nine hundred and sixty one were located. Sixty leases for tracts of three miles square, and three hundred and seventeen for tracts of one mile square were perfected, and mining companies organized under them."—FOSTER & WHITNEY, *Geological Report on the Lake Superior Land District*, I. p. 15.

"In the summer of 1844 * * * the first mining operations were commenced on leases secured the year before * * * and discoveries of veins and deposits of copper in the rock were made. When these facts were reported in the eastern cities, of course with many exaggerations, a great excitement or *copper fever* was the result, and in 1845 the shores of Keweenaw Point were whitened with

The following columns—compiled from every available source of information,—contain an approximate account of the produce, from the autumn of 1844 to the end of 1865.

Years.	Copper. Fine. Tons *Avoir.*	Years.	Copper. Crude. Tons *Avoir.*	Copper. Fine. Tons *Avoir.*
1845	12 * † ‡	1852	—	792 * † ‡
1846	26 * † ‡	1853	—	1,297 * † ‡
1847	213 * † ‡	1854	2,054 ‡	1,563 §
1848	461 * † ‡	1855	2,854 ‡	2,366 §
1849	672 * † ‡	1856	5,112 ‡	3,214 §
1850	572 * † ‡	1857	5,142 ‡	3,884 §
1851	779 * † ‡	1858	5,264 ‡	3,580 ‖

the tents of speculators and so-called geologists. Many hundred *permits*, or rights to select and locate on tracts of land for mining purposes, were issued by the Department, and three hundred and seventy seven leases were granted. Most of the tracts covered by these were taken at random, and without any explorations whatever; indeed, a large portion of them were on rocks which do not contain any metalliferous veins at all, or in which the veins, when they do occur, are not found to be productive. In 1846 the excitement reached its climax; and the speculations were continued as long as it was possible to find purchasers. * * * But every such mania must have an end, and in 1847 the bubble had burst, and the country was almost deserted. Only half a dozen companies, out of all that had been formed, were actually engaged in mining."
Whitney, *Metallic Wealth of the United States*, p. 249.

Rivot, *Annales des Mines*, 5me Série, VII. p. 181. Snow, *Ante*, p. 459, Note *.

* Whitney, *Metallic Wealth of the United States*, p. 304.

† Rivot, *Annales des Mines*, 5me Série, VII. p. 327.

‡ *Report of a Joint Committee of the Senate and Representatives to the Legislature of Michigan*, XIX. (1861) p. 5.

§ John Simpkins, Esq., of New York, Metal Broker, MSS.

‖ *New York Daily Tribune*, 19th January, 1859. *Mining Journal*, XXIX. (12th February, 1859) p. 103.

Years.	Copper. Crude. Tons *Avoir.*	Copper. Fine. Tons *Avoir.*	Years.	Copper. Crude. Tons *Avoir.*	Copper. Fine. Tons *Avoir.*
1859 ...	6,469 * †	4,543 §	1863 ..	7,632 ††	5,342 **
1860 ...	7,674 * ‡	5,389 §	1864 ..	7,645 ‡‡ §§	5,352 ** §§
1861 ..	9,229 ‖	6,607 ‖	1865 ..	8,904 ‖‖	6,233 **
1862 ..	8,064 ¶	5,645 **			

Thus, in less than twenty-two years after the commencement of systematic mining, this region has yielded some 58,542 *(Avoir.)* tons of fine copper.

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* *Report of the Senate and Representatives of Michigan*, XIX. (1861) p. 5.

† *The Joint Committee of the Senate and Representatives of Michigan*, & the *Detroit Daily Tribune*	state the returns of 1859 to have been	7,245 United States, or	6,469 *Avoir.*,	Tons;
The *Portage Lake Mining Gazette*, III., & the *United States Railroad & Mining Register*, v. (2nd Feb. 1861) No. 37,	...... „	6,041 „	5,394	„
‡ The *United States Railway and Mining Register*, v. (2nd Feb. 1861) No. 37..	states the returns in 1860 to have been	8,578 „	7.659	„
The *Detroit Daily Tribune*......	„	8,592 „	7,671	„
„ *Portage Lake Mining Gazette* III. (1861)................	„	8,614 „	7,691	„
„ *Joint Committee of the Senate and Representatives of Michigan*, XIX.	„	9,200 „	8,214	„

§ " 8,543·4 tons of rough are equal to 6,000 tons of ingot copper."
United States Railway and Mining Register, v. (2nd Feb., 1861) No. 37.

‖ Dupee, Beck, and Sayles. *Portage Lake Mining Gazette*, III.

¶ The *Mining Journal*, XXXXIII. (11th April, 1862) p. 258, ...	states the returns in 1862 to have been	9,015 United States, or	8,049 *Avoir.*,	Tons.
The *Mining Gazette*	„	9,019 „	8,053	„
„ *Ontonagon Miner*	„	9,062 „	8,091	„

** Crude metal, estimated to yield 70 per cent. of fine copper.

†† *Ontonagon Miner.*

‡‡ *Lake Superior Mining Journal. Mining Journal*, XXXV. (8th April, 1865).

§§ Bauerman, *Quarterly Journal of the Geological Society*, XXII. (Nov. 1866), p. 456.

‖‖ *Mining Journal*, XXXVI. (Feb. 3rd, 1866), p. 66.

For most of these particulars the Author is indebted to his Friend, Ebenezer North Willcox, Esq., of White Woods, near Detroit.

On the Metalliferous Deposits of Gloucester, in New Brunswick.

Notwithstanding great part of Gloucester is still covered with virgin forests, many natural sections of the granite, slate, sandstone, conglomerate, and shale are exposed on the coast, and in the banks of several rivers, which converge towards Bathurst the County-town.*

(I.) The granite rises from beneath other rocks near the Bay de Chaleur, and extends thence in a south-westerly direction to the confines of the Province.†

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* "The town of Bathurst is situated on either side of a harbour, or bay, some six or eight miles in depth, and four or five wide, which is formed by the mouths of three rivers—the Tatagouche, the Middle, and the Nepisiguit—which fall into it."—Johnston, *Notes on North America,* II. (1845) p. 250.

† Lyell, *Travels in the United States,* II. (1845) p. 250, *Pl. II.*

"The granite, gneiss, and mica-slate form a broad riband extending across the Province, between two bands of clay-slate rocks."

Johnston, *Report on the Agricultural capabilities of New Brunswick* (Second Edition, Fredericton, 1850), p. 8.

"The primary rocks of granite, gneiss, and mica-slate, form a broad belt extending directly across the Province, near its centre, in a north-easterly direction. * * * It enters the Province from the United States above Woodstock, embracing Mars Hill near the Des Chutes river, and the range of hills known as the Tobique mountains, all which, however, are less than 2,000 feet in height, except one which rises to the height of 2,170 feet. At the western end, this belt of hilly country, is supposed to be 40 miles wide; but it narrows gradually in its north-easterly course, and the hills decrease in height, until they finally disappear before reaching the Bay of Chaleur near Bathurst."

Perley, *Hand Book of Information for Emigrants* (London, 1857), p. 31.

"A low range of granite stretches from the Atlantic coast of Maine to the Bay of Chaleurs."—Hind, *Preliminary Report on the Geology of New Brunswick* (Fredericton, 1865), p. 41.

"The great central belt [of granite], entering the Province from the State of Maine, passes through the counties of York, Northumberland, and Gloucester, and extends to within a short distance of the Bay of Chaleur, at Bathurst."

Bailey, *Observations on the Geology of Southern New Brunswick* (Fredericton, 1865), p. 84.

It occurs on both the Little and the Middle (Nepisiguit) rivers; and has been traced along the banks and in the bed of the (Big-river) Nepisiguit, at intervals, for nearly twelve miles towards the south. Greyish-white or pale-pink felspar, semi-translucent or milk-white quartz, and dark mica, are the common ingredients. The structure is mostly granular; though now and then it becomes porphyritic, as large crystals of flesh-coloured felspar abound. Sometimes, however, these preserve, among themselves, a certain parallelism; and the rock then—opening in somewhat ill-defined beds—assumes rather the character of gneiss.*

At Glendinning's island, near the last rapid in the Rough-waters of the Nepisiguit, a broad felspathic dyke of porphyritic structure †—bearing 20°—30° W. of N.–E. of S.—intersects the ordinary granite. And at the falls of the Pabineau as well as at the Middle Nepisiguit the prevailing rock is traversed by narrow veins of quartzose granite; ‡ of which the greater

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* "The granite is first seen near the coast on Middle river, about a mile and a half west of the Nepisiguit, and an eighth of a mile from the Harbour. It appears on the Nepisiguit at the Rough Waters [which for] more than two miles flow over it. * * * Two and a half miles above the Pabineau falls granite also occurs in low domes on the north side of the Nepisiguit.

"At Rough Waters it consists of white felspar, black mica, and translucent quartz."—

Hind, *Preliminary Report on the Geology of New Brunswick*, pp. 42—3.

"The curious and beautiful channels of the Pabineau Falls are formed of nearly flat and water-worn masses of pinkish granite, which probably forms a great anticlinal axis."—Bailey, *Observations on the Geology of Southern New Brunswick*, p. 11 (abridged).

† "At the foot of the Rough Waters there is a felspar dyke containing red crystals of the same mineral."

Hind, *Preliminary Report on the Geology of New Brunswick*, p. 44.

‡ Henwood, *Proceedings of the Geological Society of London*, III. (1841), p. 454.

number bear 25°–40° S. of E.—N. of W., but some range 20°–25° W. of N.—E. of S.*

Earthy brown iron-ore *(gossan)*—largely mixed with quartz in one of these—is the only metallic mineral yet found in the granite.†

The granite of different localities, is divided by joints, in the undermentioned directions.

Localities.		Directions.*		
Little Nepisiguit			25° N. of W. — S. of E.	
Middle Nepisiguit	Molloy's	20° W. of N. — E. of S.		30° N. of E. — S. of W.
	,, Second spot			20° N. of E. — S. of W.
	,, Third spot			25° E. of N. — W. of S.
Nepisiguit	Falls of the Pabineau	20° W. of N. — E. of S.	25° N. of W. — S. of E.	25° E. of N. — W. of S.
	,, Second spot	20° W. of N. — E. of S.	25° N. of W. — S. of E.	
	Rough-waters	20° W. of N. — E. of S.	25° N. of W. — S. of E.	40° N. of E. — S. of W.

(II.) The slate series is of varied character.

(*a.*) A fine-grained though an irregular admixture of felspar and hornblende, thinly sprinkled with small crystals of felspar, forms sometimes a crystalline, but more frequently a thick lamellar, slate, of green, grey, or brownish hue; which dips towards the west, and

* "In 1840 the Magnetic declination observed at Dalhousie (Heron) island in the river Restigouche was 20° 15′ West."

Bayfield, *Phil. Trans*, cxxxix. (1849) p. 211. Sabine, *Ibid, Pl. XIV.*

† "Beyond their application for building purposes * * * the rocks of this series are without economical value."

Bailey, *Observations on the Geology of Southern New Brunswick*, p. 86.

either overlies, alternates with,* or is penetrated by highly felspathic, and occasionally hornblendic, granite,† in various parts of the Middle river.

The slate contains much quartz ; which occurs now and then in isolated masses, but more commonly in veins. Most of these are only a few feet, but some are several fathoms, in length ; and though usually less than an inch, one here and there is three or four inches, in width. Notwithstanding their somewhat variable direction, they often affect two distinct series ; one bearing 20°—25° E. of N.—W. of S., the other about E and W. The first coincides with one system of joints in the granite below ; ‡ but both are oblique to the cleavage. Where they interfere—a few unite ; —some are simply intersected by others ;—and, occasionally one is *(heaved)* displaced by another ; but the displacements—even of similar parallel veins by the same intersecting vein—are frequently in opposite directions.§ And sometimes the vein which intersects

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* "The granite consists of a series of very narrow belts (at least ten in number on the Miramichi) with schists and metalliferous slates between them."

HIND, *Preliminary Report on the Geology of New Brunswick*, XIII.

De Luc, *Geological Travels.* III. p. 293. William Phillips, *Geol. Trans.*, O.S., II. pp. 152—5. Sedgwick, *Cambridge Phil. Trans*, I. p. 122. Richard Thomas, *Survey of the District between Chasewater and Camborne*, pp. 10, 34, 44. Carne, *Cornwall Geol. Trans.* II. p. 74. Hawkins, *Ibid*, p. 378. von Oeynhausen & von Dechen, *Phil. Mag. & Annals*, V. pp. 241—2. Boase, *Cornwall Geol. Trans.*, IV. p. 303. Henwood, *Phil. Mag. & Annals*, X. p. 360 ; *Cornwall Geol. Trans.*, V. pp. 50,—8, 61, 71, 96, 148, *Tables VII., XXI., XLIII., LIII., LVIII., Pl. VI. fig.* 5.

† "At the Middle river the granite is overlaid by thick-bedded greenish slate ; which is traversed, near the junction by numerous veins of granite."

HENWOOD, *Proceedings of the Geological Society of London*, III. p. 454.

‡ *Ante*, p. 492.

§ Thomas, *Survey of the District between Chasewater and Camborne*, p. 22. *Ante*, p. 183, Note.

in one spot, is itself intersected in another. All these, however, are severed by beds and narrow veins of granite.

In the same neighbourhood a broad band of felspar porphyry * interlies the slate, conforms to its cleavage, and shades into it gradually on either side.

Neither metal nor ore, of any kind, has yet been found in the vicinity.

(*b.*) At Long Meadow, on the Nepisiguit, many irregular concretions, and short, crooked, veins of quartz, are enveloped in a thin body of much-contorted, green, chloritic slate,† which separates the granite ‡ from the sandstone.

From the Middle Landing to the Red Brook the slate still abounds in chlorite; but disintegrated felspar is not uncommon, and scales of red iron-ore often face both the planes of cleavage and the joints.

(*c.*) At Daly's—an eastern settlement—on the Tattagouche §—the slate is homogenous, deep-blue,—and of silky lustre. Its planes of cleavage—which dip towards the north-west—are interlaid by short, thin, conformable beds and small concretions of quartz, slightly sprinkled with iron-pyrites, and minute quantities of yellow copper-ore.

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* Henwood, *Proceedings of the Royal Geological Society of Cornwall*, 9th Oct., 1840.

† "Near the Long Meadow a greenish slate-rock is in contact with the granite." Henwood, *Proceedings of the Geological Society of London*, III. p. 454.

‡ *Ante*, p. 491.

§ In the Maps of the Society for the Diffusion of Useful Knowledge (130—1) this river is called the Jittingouche.

(*d.*) About eight miles north-west of Bathurst the Tattagouche rushes through a wooded ravine, scarcely a stone-throw in width, but, perhaps, one hundred feet in depth; where—from the different hardness, and the unequal wear, of various parts of its bed,—it forms a singularly beautiful cascade.

The rocks immediately below the fall, and their continuation in either bank, consist mostly of greenish chlorite irregularly banded with brown felspar; opening—obliquely to such bedding—in a somewhat imperfect lamination, which dips towards the south.

The precipice is flinty-slate of chocolate hue; divided, by short curved joints, into small lenticular masses, of compact structure at the surface,* but slightly schistose underground.

The succeeding rocks are generally thick lamellar, but occasionally they are fissile; their colours are of every variety between chocolate-brown and light-pink, yet sometimes they are either shaded with green, or mottled with black and white. Isolated cubic crystals, as well of vitreous copper-ore as of iron-pyrites, occur at considerable intervals; and from this part of the series, — but from no other, — a few specimens of *Crinoïdea* have been obtained.† The grey and black

* "Close to an interesting fall of the Tatagouche, where it partly cuts its way through, and partly falls over, the edges of hardened slate-rocks, a manganese mine [was formerly wrought]."—Johnston, *Notes on North America*, ii. p. 10.

† "In a reddish-brown slate near the Tatagouche falls some portions of an *Encrinite* were found."

Henwood, *Proceedings of the Geological Society of London*, iii. p. 454.

"At the falls of the Tattagouche * * * the beds of slates are highly colored,

oxides of manganese are often separately aggregated,—but are occasionally mixed with brown iron-ore,—in short, narrow, lenticular masses, small shapeless lumps, and thin strings of quartz flecked with slaty matter; which—generally conforming to the planes of cleavage, though now and then throwing off *branches* on either side,—are, at intervals, enclosed in the slate, for a width of several fathoms.*

(*e.*) The rocks next in succession have much the same composition and structure, but are of bluish-green hue, and silky lustre. They alternate, at wide intervals, with bands of greenstone; which, unlike the flinty-slate at the falls,—are compact underground, but schistose at the surface. Both the clay-slate and the greenstone are interlaid by conformable beds of rather different character; which are usually several

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in some parts red, in others deep brown or black, and strongly resemble those near the Falls of the Nepisiguit. They cross the stream with a strike E. 10° S., having a dip of about 50° towards the South."

Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 12.

Hind, *Preliminary Report on the Geology of New Brunswick*, p. 149.

* "At the Tattagouche falls a reddish-brown slate contains many small vermicular and nodular masses of the oxide of manganese."

Henwood, *Proceedings of the Geological Society of London*, iii. p. 454.

"Grey oxide of manganese, highly crystallized and of fine quality, has been worked to some extent on the Tattagouche river, near Bathurst, and thence shipped to England."—Perley, *Hand Book of New Brunswick*, p. 36.

"The manganese is found in veins of various sizes, imbedded in quartz, and running without much regularity through the slates, which are everywhere stained with it. The manganese, which is the black oxide, is highly crystallized and affords very handsome and brilliant specimens, the crystals being sometimes as much as half an inch long, and grouped in fibrous, radiating, and stellate forms. The lode-stone of the manganese is both heavy-spar and quartz, the lode-walls being slates."

Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 13.

fathoms—though at times of but a few feet—in length; and commonly from twelve to eighteen inches—yet now and then of three or four feet—in width. Their central parts consist mostly of quartz; but towards their extremities they shade gradually into the slate, and are no longer identified. Several of these, and a few of the joints, contain quantities of iron-pyrites; sometimes slightly mixed and thinly sprinkled with yellow copper-ore.*

(*f.*) Near Clarke's camp, an upper part of the same river, and at Armstrong's brook, one of its tributaries, homogenous, blue, clay-slates,† which alternate with narrow bands of greenstone, are interlaid by conformable beds of quartz mixed, more or less, with slaty clay, calcareous-spar, and galena, as well as with iron and copper pyrites. Several such beds have been opened at both places, but in vain.

(*g.*) Within a short distance of Bathurst the Little (river) Nepisiguit falls, in a picturesque cascade, over a broad bed of greenstone; disposed in layers alternately of compact and of schistose structure; fine-grained in some, but coarse and porphyritic in other, places. The cleavage of the rather fissile, homogenous,

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* "The copper lodes do not approach those of manganese, although both are imbedded in metamorphic slates. There is, however, a marked difference of color between them; the manganese rocks being reddish and approaching black, while those bearing copper are of a bluish tint. The two are conformable—*i.e.* their planes of stratification are parallel—the manganese being superior. Both are inclined at a very high angle. * * * The lodes containing the copper ore are numerous, there being no fewer than seven within sixty feet. * * * They are composed of quartz, rocks called *flugan* and *gozzan* by the miners, with *mundic* or iron pyrites, and the ore, copper pyrites."—Bailey, *Report*, p. 13.

† Henwood, *Proceedings of the Geological Society of London*, iii. p. 454.

glossy, bluish-grey, slate it interlies is, on both sides, parallel to that of the schistose greenstone. Both above and below the fall, the clay-slate, for a width of several fathoms on either side of the broad band, is likewise interlaid by conformable beds, composed chiefly of quartz, yet here and there mixed with slaty matter, scaly red iron-ore, and iron pyrites.* After short ranges, however, all such beds merge in the *(Country)* slate.

(*h.*) From ten to twelve miles up the Middle (river) Nepisiguit the quartzose clay-slate which prevails is interlaid by lenticular bodies of quartz; but—though enclosing isolated masses of slate—they afford no trace of ore.

(*i.*) At the Narrows of the (Big river) Nepisiguit homogenous, glossy, deep-blue clay-slate alternates with broad bands of quartz, here and there friable, but generally of granular structure. These are, in many places, heavily charged with iron-pyrites; which has yielded to atmospheric influence and deeply tinged its matrix.†

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* "Among the specimens shown me by Mr. Baldwin, formerly Sheriff of Gloucester County, was one of auriferous quartz, which he had found upon Grant's Brook, a branch of the Little Nepisiguit several years ago. Its surface exhibited numerous branching veins of gold, and promissed to yield, by crushing, considerably more. He had since hunted for more in the same locality, but without success."

Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 14.

† Red slates, similar to those which are found near Woodstock, are seen a little above Nine Mile Brook. The river runs on the strike of the rock here, and the purple-red slates which occur five miles higher up the stream, are repetitions of the red slates, more deeply colored with manganese than iron. Indeed, it may be said that for a distance of six miles the river appears to flow on or close to the belt of red slates, with their iron and manganese ores."

Hind, *Preliminary Report on the Geology of New Brunswick*, p. 148.

(*j*) In the crumpled and contorted chloritic slate,* which prevails near the Middle Landing, disintegrated felspar is occasionally a large ingredient. The joints are often faced with minute crystals of quartz, and filled with earthy red iron-ore.

(*k*.) Between the Middle Landing and the Portage-brook spheroidal concretions of argillaceous matter abound in certain beds which alternate with the ordinary thick-lamellar, bluish-grey, clay-slate. At and near the water's edge, it contains a few thin layers of quartz sprinkled with iron-pyrites; but, after very short courses, they dwindle and disappear.

(*l*.) The Chain of Rocks consists of fine-grained greenstone-slate.

(*m*.) The Grand fall of the Nepisiguit has worn a deep pit in the, slightly quartz-veined, dark-blue clay-slate at its foot.†

(*n*.) At the edge of the fall globular and reniform masses of quartz, crystals of felspar, and lamellar hornblende form thick beds; interlaid by a band of similar ingredients, but of compact structure, in one spot; and by lenticular bodies of quartz, said to contain copper-pyrites, in other places.‡

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* *Ante*, p. 494.

† "Below the Falls, and close to the first Salmon Pool there is a belt of glistening talcose-micaceous schist, * * * of a brilliant and lustrous golden color."—Hind, *Preliminary Report on the Geology of New Brunswick*, p. 148.

"All the rocks in this vicinity are highly ferruginous, the slates being sometimes micaceous, and at others containing cubical crystals of the sulphuret of iron."—Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 10.

In this pool two Indian boatmen, who accompanied the writer, speared, by torch-light, twenty-three salmon in an hour.

‡ "The slates just below the Falls are porphyritic, but a cursory examination failed to detect in them any traces of copper. * * *

The following columns show the *strike* and dip of the cleavage, as well as the directions of certain joints, in the slate-rocks already mentioned.

Localities.		Cleavage. Direction.	Cleavage. Dip.	Joints. Direction.
Tattagouche	Daly's	25° E. of N. — W. of S.	N.W. 60°-70°	
	Falls*	20° N. of E. —S. of W.	S. 60°—70°	
	Above Falls	E.—W.	S. 45°—50°	
	Clarke's camp	N.E.-S.W.	S.E. 65°	S.E.—N.W.
		25° E. of N. —W. of S.	S.E. 70°	25° S. of E. —N. of W.
	Armstrong's brook	25° E. of N. —W. of S.	S.E. 70°	25° S. of E. —N. of W.
Little Nepisiguit		25° E. of N. — W. of S.	S.W. 70°	S E.—N.W.
Middle Nepisiguit		25° S. of E. — N. of W.		
Nepisiguit	Narrows	25° W. of N. — E. of S.	S.W.	
	Long Meadow †	—	Contorted.	
	Middle Landing†	40° W. of N. — E. of S.		

"At the Grand Falls a highly siliceous rock, of slaty character, was seen to contain specks of sulphuret of copper."
Hind, *Preliminary Report on the Geology of New Brunswick*, p. 147—8.

"Contorted slates form the wild scenery of the Nepisiguit Falls."
Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 10.

"On the lower Nepisiguit, near the Grand Falls, I collected the sand and gravel which had been lodged in crevices on the side of a deep declivity down which a small stream flows in spring and autumn. I washed about one gallon of the sand and found several small grains, two filaments, and some very fine gold."—Hind, *Preliminary Report on the Geology of New Brunswick*, p. 224.

* "These beds of slate * * * cross the stream with a strike E. 10° S., having a dip of about 50° towards the south."—Bailey, *Report*, p. 13.

† "Pursuing our way from the Falls, we pass over sandstones and slates dipping westward."—*Ibid*, p. 10.

Localities.		Cleavage. Direction.	Dip.
Nepisiguit	A furlong below Grand Fall*..	40° W. of N. — E. of S.	S.W. 60°–70°
	Below G. Fall*	40° W. of N. — E. of S.	S.W. 70°
	Grand Fall ..	40° W. of N. — E. of S.	S.W. 70°

(III.) The succeeding rocks are conglomerates, sandstones, and shales.

(*a.*) About two furlongs below Blackstock's mill on the Tattagouche, the conglomerate—which abounds in rounded masses of slate and quartz,—rests, in almost horizontal beds, on a fissile, greenish, but somewhat variegated, slate; of which the cleavage dips about 70° towards the S.W.†

(*b.*) The thin stratum of contorted slate, which rests on granite at the Long Meadow,‡ is overlaid by nearly horizontal beds of conglomerate,§ and these

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* "Below the Falls, the talco-micaceous schist [has] an easterly dip."
HIND, *Preliminary Report on the Geology of New Brunswick*, p. 148.

† "The clay-slate * * * which forms both banks of the Tattagouche * * * is overlaid near Blackstock's mill by the * * * conglomerate of the coal-measures."—HENWOOD, *Proceedings of the Geological Society*, III. p. 454.

"The country over which we passed [between Dalhousie and Bathurst] consisted of the highly-inclined upper Silurian beds, with occasional limestones occurring among them, * * * . Over these rocks, in many places were spread, in patches more or less extensive, horizontal old red-sandstone beds."
JOHNSTON, *Notes on North America*, II. p. 2.

‡ *Ante*, p. 494.

§ "Near the Long Meadow a very much contorted greenish slate-rock, which rests on the granite is overlaid by a coarse quartzose conglomerate, with apparently a ferruginous basis."
HENWOOD, *Proceedings of the Geological Society*, III. p. 454.

"Two miles below the Second Landing [nearly horizontal strata belonging to the *Bonaventure* formation] cover up rocks belonging to the *Quebec* Group; and on the north side of the river they form cliffs 20 feet high, consisting of brick-red shales and sandstones, resting upon a coarse conglomerate."
HIND, *Preliminary Report on the Geology of New Brunswick*, pp. 57,—9.

are succeeded by layers of siliceous sandstone deeply tinged with iron.

(*c.*) From the Red Brook upward a similar conglomerate rests almost horizontally on the granite.*

Notwithstanding a dyke of porphyry and veins of granite traverse the granitic mass within a short distance,† and similar veins penetrate the slate at the Tattagouche,‡ neither one nor other enters either the conglomerate, sandstone, or shale.

(*d.*) A few fathoms above the high-road from Bathurst to Miramichi the left bank of the Nepisiguit presents the following section §;—

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* "From within a mile of Bathurst to the Pabineau falls the granite is surmounted by conglomerates and sandstones of the coal-measures; the beds of which are almost exactly parallel to the surface of the rock beneath."

Henwood, *Proceedings of the Geological Society*, III. p. 454.

"The Rough Waters, more than two miles long, flow over granite, but on either side the *Bonaventure* [conglomerate and sandstone] formation may be recognized reposing horizontally upon it, and filling all depressions."

Hind, *Preliminary Report on the Geology of New Brunswick*, p. 59.

Messrs. Hind and Bailey describe various parts, and tributaries, of the Nepisiguit by names different from those by which they were known, to the inhabitants of Bathurst, and to the Indian-boatmen who accompanied the writer on that river, in 1840.

† *Ante*, p. 491.

‡ *Ante*, p. 494.

§ "This formation was seen at Bathurst, by Sir William Edmond Logan, and described by him in the *Geology of Canada*. * * * The following section of the strata occurs at and near the abandoned mine, on the Nepisiguit;—

	feet
1. Chocolate-red micaceo-arenaceous shale, with casts of shrinkage cracks .	30·
2. White quartzose conglomerate, the thickest part of which is two feet, diminishing in one direction to two inches, in the space of 15 yards. The bottom is very white, and contains quartz pebbles, some which are an inch in diameter	1·
3. Whitish-red argillo-arenaceous shale, forming a passage to the next bed below	0.5
Carried forward........	31·5

North—north-east.	feet.		South—south-west.	feet.
1. *Drift*, containing pebbles of granite, slate, & quartz ..	2	A joint, bearing 25° E. of N.—W. of S., less than an inch wide.	1. *Drift*, containing pebbles of granite, slate, & quartz ..	2
2. Reddish-brown siliceo-micaceous sandstone	30		2. Reddish-brown siliceo-micaceous sandstone	30
3. QUARTZOSE CONGLOMERATE.	1		3. *Blue argillaceous shale*, containing lignite and the remains of plants, impregnated in some places with copper-ores.............	0—3
4. *Blue argillaceous shale*, containing lignite and the remains of plants, impregnated in some places with copper-ores	0—3		4. QUARTZOSE CONGLOMERATE.	1
5. Siliceous sandstone .. thickness unseen.			5. Siliceous sandstone .. thickness unseen.	

(*e*.) About two furlongs further up the river, the materials—in a lower part of the bank—are somewhat differently disposed ;—

	feet.
1. *Drift*, containing pebbles of granite, slate, and quartz	2·
2. Coarse quartzose conglomerate	1·5
3. Reddish-brown siliceo-micaceous sandstone	1·5
4. Quartzose conglomerate, interlaid by a few thin beds of sandstone..	3—5·
5. Brownish-red sandstone, interlaid by thin beds of greenish hue	1·5
6. Blue argillaceous shale, containing lignite and the remains of plants; slightly penetrated in some places with copper-ores.	1—4·
7. Quartzose conglomerate	thickness unseen.

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	feet.
Brought forward........	31·5
4. Whitish-red argillo-arenaceous shale in parallel layers; this bed thins out about 30 yards up the stream. It is charged with the remains of broken plants, some of which are replaced by the vitreous sulphuret of copper, coated with a thin covering of green carbonate. Some are in part replaced by the copper ore, and partly converted into coal. Small nodules of the sulphuret of copper also occur, chiefly in the lower part, and traces of nickel are said to have been found in them. The greatest thickness of the bed is four feet; its average	2·
5. White quartzose conglomerate, similar to that of the summit. This does not thin out in the distance examined, about 50 yards	4·
6. Red Sandstone conglomerate with white quartz pebbles; of which some would weigh three ounces [each]	6·
7. Red Shale	6·
8. Red Sandstone conglomerate, with quartz pebbles, some weighing a pound and a half [each]	10·
	59·5

HIND, *Preliminary Report on the Geology of New Brunswick*, pp. 57,—9.

In those portions of the shale, which are numbered 3 on the S.—S.W. side of the joint and 4 on the N.—N.E. side of it in the first section, two *(levels)* drifts—one about twenty, the other nearly thirty, fathoms long—have been opened; in the part marked 6 in the second section another—though a much smaller—opening has been made; and, at some distance from all three, a shaft was sunk to the same horizon.

The shale presents many slight undulations; but, on the whole, it dips 6°—10° towards the E. Its thickness seldom exceeds four feet, and is generally between two and three; but in at least one instance it gradually dwindles and at length dies out; a second thin bed, of nearly similar character, however, appears a few feet above the last traces of the first. The rock, when newly broken, is often thick-lamellar; but a slight exposure developes its fissile character; and, under the influences of heat and moisture, it is rapidly degraded.

The principal bed of shale is rich in the remains of plants; but they are often broken and decomposed. Amongst them, however, the following have been identified by William Lonsdale, Esq., F.G.S., Sir Charles Lyell, Bart., D.C.L., F.R.S., and Robert Etheridge, Esq., F.R.S.E., F.G.S.: viz.—*Pinnularia capillacea,** *Pecopteris Cistii,** *P. ovata,** *P. pteroïdes,**† *P. muricata,**† *P. Sillimani* (?),† *Neuropteris Loshii,** *Sphenopteris elegans,** *S. acutifolia,** *S. Höninghausi,**

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* Named by Robert Etheridge, Esq., F.R.S.E., F.G.S., Palæontologist to the Geological Survey of Great Britain.

† ,, Sir Charles Lyell, Bt., D.C.L., F.R.S., *Travels in North America*, First Series, II. pp. 198, 201,—2.

*Calamites Suckovii,** *C. dubius,* ‡ *Lepidodendron,** *L. undulatum,*†‡ *Asterophyllites longifolia,** *A. equisetiformis,** *A. cuneata,** *A. tuberculata.** Other genera and species have since been found, in the same neighbourhood, by Sir William Edmond Logan, LL.D., F.R.S.§

(*f.*) At Parrot's-brook, near the Capes, an erect fossil tree,|| of about fourteen inches in diameter and some twenty-two feet in length, was (1840) exposed in the face of the cliff. It was rooted in a thick bed of argillaceous shale, which rested on a thin seam of coal; but at different heights its trunk was enveloped in alternate

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† „ Sir Charles Lyell, Bt., D.C.L., F.R.S., *Travels in North America* First Series, II. pp. 198, 201,—2.

‡ „ William Lonsdale, Esq., F.G.S., late Assistant Secretary and Curator of the Geological Society.

§ The undermentioned plants have been discovered, near the Bay de Chaleur, by Sir William Edmond Logan, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada: viz.—*Calamites Cistii, Asterophyllites grandis, Annularia galoides, Sphenophyllum saxifragifolium, S. emarginatum, Næggerathia dispar, Neuropteris rarinervis, N. Loshii, Odontopteris Schlotheimii, Sphenopteris Canadensis, S. obtusiloba* (?), *Alethopteris nervosa, A. Serlii, A. grandis, Beinertia Gœpperti, Lepidodendron verticillatum, Cordaites borassifolia.*

Dawson, *Quarterly Journal of the Geological Society*, XXII. pp. 151—164.

|| Jackson & Alger, *Mineralogy* &c. *of Nova Scotia,* (1832) pp. 69, 70. Gesner, *Geology* &c. *of Nova Scotia* (1836), p. 158. Lindley, *Penny Cyclopædia,* VII. p. 294. Binney, *Reports of the British Association for* 1842, Part II. p. 50. Lyell, *Travels in North America,* First Series, II. p. 195; *Proceedings of the Geological Society,* IV. p. 176. Dawes, *Ibid,* p. 292. Binney, *Lond., Edin., & Dublin Phil. Mag.,* XXIV. p. 167. Binney & Harkness, *Ibid,* XXVII. p. 241. Dawson, *Quarterly Journal of the Geological Society,* II. p. 136. Lyell, *Ibid,* p. 171. Binney, *Ibid,* p. 390. Brown, *Ibid,* p. 393. Lyell, *Ibid,* III. p. 262. Brown, *Ibid,* IV. p. 46; V. p. 354. Binney, *Ibid,* VI. p. 20. Brown, *Ibid,* p. 128. Dawson, *Ibid,* VII. p. 124. Jackson, *Report on the Albert Coal Mine,* p. 8. Dawson, *Quarterly Journal of the Geological Society,* X. p. 1. Logan, *Ibid,* p. 39. Dawson, *Acadian Geology,* pp. 129,—59,—61—85. Phillips, *Quarterly Journal of the Geological Society,* XIV. pp. 90,—8. Dawson, *Ibid,* XV. pp. 67, 635; XVI. p. 269; XVII. p. 522; XVIII. p. 5; XXII. pp. 104, 108—25,—28,—32,—34,—50—1,—9.

layers of carbonaceous shale rich in the remains of plants, and of almost barren ferruginous sandstone; fragments of both which strewed the beach. One well-marked system of persistent joints bears about 25° E. of N.—W. of S.; but innumerable others, in different directions, though of shorter range, give some of the surfaces a tessellated aspect.*

Lignite is largely mixed with the other remains of plants in the shale wrought—as already mentioned—at the *Victoria* mine near Bathurst; but pieces of more than a few inches in length are rare.† Whether

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* Jukes, *Quarterly Journal of the Geological Society*, III. p. 248.

† "Wherever traces of woody fibre occur, in the soft bluish shale, copper-appears to have been deposited. The largest quantity of ore occurs, however, in small concretions, the inner parts of which are usually composed of vitreous copper and the outer of copper-pyrites, or the reverse; whilst a few nodules consist of vitreous copper, and still fewer entirely of pyrites. Thin scales of the green and blue carbonates of copper invest the other ores. Although this impregnation has been found over a considerable tract, the ores obtained have not repaid the expense.

"Some portions of the shale give out, on being broken, a most powerful odour of garlic."—Henwood, *Proceedings of the Geological Society*, III. pp. 454—5.

"The Gloucester Mining Company expended much labour and money in searching for copper at the mouth of the Great Nepisiguit."

Gesner, *New Brunswick*, p. 198.

"Grey sulphuret of copper has been found in small quantities * * * on the left bank of the river Nepisiguit, near Bathurst, and a Company was formed some years since to work the deposit; but the irregular distribution of the mineral rendered their operations uncertain, and the mine has been abandoned."

Perley, *Hand Book of New Brunswick*, p. 37.

"The Bonaventure strata contain fossil plants, which about a mile above Bathurst, on the Nepisiguit, have been replaced in part by sulphuret of copper, which again has become converted into the carbonate at the surface. * * * The replacement of vegetable matter by the ores of copper is by no means uncommon; it has been described by Dr. Dawson as occurring * * * in some of the lower beds on the Joggins coast in Nova Scotia, and Sir William Logan states that a combination of coal and grey sulphuret of copper occupies the forms of vegetable remains in a regular eighteen-inch bed which seems to crop out all around a considerable mountain in the Spanish Pyrenees."—Hind, *Preliminary Report on the Geology of New Brunswick*, pp. 57—8 (Abridged).

it has been derived from a single, or from more than

"In light bluish shales, sandstones, and both fine, coarse, and crumbling conglomerates, * * * about a quarter of a mile from the Nepisiguit bridge, copper was found and removed to the extent of 20 or 30 tons. It consisted of grey copper and the green carbonate intimately associated with the mineral called lignite, a peculiar variety of coal. * * * The distribution of the ore, being found irregular, and the whole deposit uncertain in its character, the enterprize was abandoned. At the time of my visit very little of the pure copper-bearing lignite could be found. The few specimens obtained were removed from a fine bluish clay, interstratified with the sandstones and conglomerates. These latter, like the lignite, are charged with copper, and a general greenish appearance, due to the weathering of that metal, is seen along the bank for a considerable distance."

Bailey, *Report on the Mines and Minerals of New Brunswick*, p. 11.

"On the banks of the Carriboo river, two miles from where it empties itself into the Gulf of St. Lawrence, occurs a bed of copper ore, included between the strata of sandstone passing into coarse conglomerate. It is associated with lignites of enormous size, which generally lie over the copper ore. * * * The lignites are black, and some of them resemble common charcoal. Some are fibrous, and exhibit evident traces of the organized structure of plants. * * * The lignite forms thin layers over masses of the copper ore, which sometimes presents substitutions or casts of culmiferous plants. The lignite sometimes contains minute flattened crystals of red oxide of copper. Green and blue carbonates of copper invest some of the lignites, fill interstices in the sandstone, and encrust the masses of vitreous copper ore. This valuable substance occurs in beds of from two to four inches thick, which, covered with lignites, alternate with each other, the lowest bed being thickest and most compact. The most compact variety is 5·7, but the granular varieties seldom exceed 4·8 or 5· in specific gravity. This ore yielded by our analysis

Copper	79·5
Sulphur........	18·0
Iron	2·5
	100· "

Jackson & Alger, *Geology and Mineralogy of Nova Scotia*, pp. 73—6. (Abridged.)

"About eight miles north of Pictou, on the banks of the Carriboo River there is a bed of copper ore, enveloped and intermixed with lignites. Large trees, in some instances retaining the vegetable fibre of the wood, and impressions of the leaves, bark, and all those figures so common on the surface of the living plant, are sometimes wholly transformed into lignite, [whilst] in other cases the ancient herbage of a productive climate [has become] half stone, half coal. * * * In breaking open masses of these once majestic trees, now transformed into jet and bituminous lignite, the green carbonate of copper often appears, forming an efflorescence in their crevices, The blue carbonate, and the red oxide of copper, also appear occasionally, both in the lignite and the sandstone. The copper ore

one, kind of wood has not been ascertained. In many

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is deposited in narrow veins, from one to four inches in thickness, and alternating with the lignite and sandstone. * * * Compact masses [are] of the specific gravity of 5·5."—Gesner, *Remarks on the Geology and Mineralogy of Nova Scotia*, pp. 139—40. (Abridged.)

Near "Seaman's Brook in Mill Cove * * * we see in the low cliff and in the shore reefs beds of reddish and greyish sandstone, alternating with reddish shales. * * * In a few places we find amongst these beds layers of gypsum and of sandy limestone. In several of the grey beds there are fragments of trunks and branches of trees, converted into coal; [and] associated with these remains, we find in four of the beds small quantities of the grey sulphuret and green carbonate of copper."—Dawson, *Acadian Geology*, p. 124.

"The principal fossils found near Pictou are *Calamites*, *Lepidodendron*, *Endogenites*, coniferous wood, ferns, *Artisia*, and carbonized fragments of wood impregnated with iron pyrites and with sulphuret and carbonate of copper."
Ibid, p. 252.

"In the coast-section westward of the entrance to Pictou harbour * * * much red sandstone appears; and a bed of limestone from two to three feet thick, and a small bed of coal have been discovered. Some grey sandstones also appear: in one of which there are numerous fragments of carbonized wood, containing sulphuret and carbonate of copper,"—*Ibid*, p. 253.

"In all these places the principal ore is the grey sulphuret of the metal, with films and coatings of the green carbonate. * * * The only reason which prevents them from being worked, is the conviction that the deposits are too limited to be of economical importance."—*Ibid*, p. 267.

"At the Zavods of Yugofski and Motovilika * * * cupriferous grits, sandstones, and shale have been largely excavated in several places. These beds, which are pierced by shafts from 35 to 130 feet deep, consist of thick flaglike grits of grey and dingy colour, rarely ferruginous, sometimes of greenish hue, and occasionally slightly calcareous, with courses of red and grey ribboned marl and shale. The ores of copper, chiefly the green carbonate, are disseminated at intervals through all the beds, but in this district the grits are the most cupriferous. On the whole, the lower beds are more grey and dark coloured, and the upper strata redder. Plants of at least twenty species diversify the series in this locality, and in some of the lower they are so numerous as to have given rise to thin seams of coal, occasionally from two to three feet thick. Concretions, often cupriferous, six to eight inches long, occur here and there, and they have been generally formed around carbonized stems of plants. Both here, and in other places, the copper ores are very frequently found to be arranged in the interstices, and around the fossilized stems and branches of plants; exhibiting passages from the common oxide of copper to the grey sulphuret or copper pyrites, and occasionally to the finer varieties of bright green acicular malachite, mixed with crystals of the blue ore. All these beds are nearly horizontal. The cupriferous beds contain 2½ per cent. of ore only, but from the wide dissemination of the ore through vast masses, its extraction is profitable. * * * In the districts near Perm, 108 cubic feet of wood are consumed to extract a *poud*, or about

specimens all trace of organic character has been obliterated; but, wherever it remains, the fibrous structure strictly conforms to the nearly horizontal bedding of the contiguous shale. Such masses are not unfrequently penetrated by irregular veins of vitreous copper; but they seldom exceed two inches in length, or one-eighth of an inch in width, and are generally much less. The minute *branches*, which, at intervals, diverge from their sides, are often crooked and unsymmetrical in the massive lignite: but—though often of different lengths and thicknesses,—they strictly interlie the fibres, wherever the original structure prevails; and thus sections of chosen specimens often display segments—and at times entire rings—alternately of vitreous copper and of lignite.

The richest portions of the formation, however, consist of rough globular and reniform concretions, sometimes as small as pease, frequently as large as pigeons' eggs, though generally about the bigness of marbles: of these—one, here and there, is wholly of copper-pyrites,—a few are entirely of vitreous copper,—and many present a nucleus of copper-pyrites enveloped in vitreous ore; but for the most

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[36·1] lbs. English of copper ore; and the cutting and converting the wood into charcoal cost 2½ roubles (about 2*s.* 1½*d.* Stg.). The *poud* of copper sells at from 32 to 34 roubles (from £1. 7*s.* 1*d.* to £1. 8*s.* 9½*d.*), and costs the Government 23 (18*s.* 9*d.*), whilst individuals whose establishments are not so expensive, produce it at 18 roubles (15*s.* 3*d.*). The Imperial Zavods near Perm afford 16,000 *pouds* (257·9 tons *Avoir.*) per annum, and as the net gain per *poud* is 10 roubles 60 copecks (nearly nine shillings), the Government profit is [169,600] roubles, or about [£7,180] sterling per annum, after defraying all costs, pay of officers included."—Murchison, de Verneuil, & von Keyserling, *Russia in Europe and the Ural Mountains*, i. pp. 144, 477.

part they consist of vitreous copper within and pyrites without. Both they and the cupriferous lignite are thinly encrusted with fibrous malachite, and slightly speckled with the blue carbonate of copper; both occur at irregular intervals, and both are most numerous where the shale inclines most towards the south.

From this part of the series, however, neither vein nor isolated granule of copper-ore has yet been obtained.

At the Capes kidney-shaped nodules of red iron-ore —made up of concentric layers alternately earthy and of diverging fibrous structure—abound in upper shales.

From 1838 to 1841 costly proceedings were carried on, by an English Company, in several parts of the district; but the returns were small, and any prospect of success, which might have lent countenance to the earlier operations, had vanished before the works were abandoned.

Note on the copper-bearing Granite of Saint Thomas in the Vale—Jamaica.

The rocks which extend in a south-easterly and north-westerly direction from Saint David to Saint Mary, * consist mostly of felspar and hornblende; in divers places, however, they are unequally mixed, not only with one another but with many other ingredients; moreover their structure is as varied as their composition.

(*a.*) Near the eastern boundary of Saint Thomas in the Vale—within this district—the Sue river, a tributary of the Agua Alta, rises in a low round-topped hill of hornblendic granite; containing porphyritic crystals of pale-pink felspar and small ill-defined masses of dark-green hornblende, imbedded in a basis of whitish, granular felspar and quartz, thinly flecked with pearl-white mica. † Of this rock a portion some four or five fathoms wide—identical with the granite on either side in composition, and, like it, divided into *slices* by joints bearing 3°—8° S. of E.—N. of W.‡—contains many egg-shaped and globular concretions of ore; of which some consist almost entirely of copper-pyrites,—others contain earthy black

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* De la Beche, *Geol, Trans.*, N.S., II. *Pl. XVIII.*

† "The Agua Alta presents a good section of [the] rocks between Stony Hill and Scot's Hall (Maroon Town); * * * the whole of which may be considered as one great mass with sometimes one ingredient predominating and sometimes another; * * * porphyries, greenstones, and syenites seem to pass into each other."—*Ibid*, p. 165.

‡ "In 1847 the Magnetic declination at Jamaica was 3° 50′ East.
Barnett, *Phil. Trans.*, CXXXIX. (1849) p. 216. Sabine, *Ibid, Pl. XIV.*

copper also,—in a few earthy brown iron-ore abounds, —and occasionally iron-glance prevails; moreover the green carbonate of copper invests most of them, and faces many of the joints. They range from the size of pease to that of walnuts, and, whilst mostly scattered in irregular groups, one here and there occurs singly. The nearest concretions are now and then connected by almost microscopic threads of pyrites; * but, excepting these, neither vein, bed, joint, crevice, nor *leader* of any kind occurs in the neighbourhood. The proportion of ore was nowhere sufficient to repay the cost of extraction.

(*b.*) Broad bands of similar hornblendic granite extend from the metalliferous body to considerable distances in the adjoining fine-grained greenstone; where particles and grains of copper-pyrites and scales of malachite may also be traced on corresponding—nearly E. & W.—lines of symmetrical structure.

Joints of a second series range about N. & S.; but they are slightly developed in the metalliferous granite.

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* "At *Wheal Vyvyan* * * * an enormous granitic *lode* bearing 20°—30° S. of W., and dipping 35°—50° N., is from 5 to 10 fathoms wide, and in some places even more. In composition it differs little from the neighbouring *country*, except that, perhaps, it may contain less mica: both are of porphyritic structure with buff and flesh-coloured crystals of felspar. The whole substance of the *lode* is thinly interspersed with tin-ore, copper-pyrites, and also with spots of iron-pyrites, and here and there a little vitreous copper. These metalliferous minerals are, however, chiefly disposed in small veins and strings, which most commonly coincide with the *lode* and the joints of the rock both in bearing and dip. The crevices, which occur at intervals, are often lined with crystals of tin-ore."—HENWOOD, *Cornwall Geol. Trans.*, v. p. 73. (Abridged).

On the Copper-bearing Sandstone of Huidobro in Spain.

The mines of Huidobro, some thirty miles N.N.E. of Burgos and about three W. of Pesadas, are opened in wooded hills, which enclose an amphitheatre on all sides, except on the north where the drainage escapes through a rocky gorge.

The rocks bear 30°—35° S. of E.—N. of W.,* dip 25°—30° S.W., and maintain—in their earthy ingredients—a tolerable uniformity throughout the district.

(*a.*) The lowest visible member of this series is a fine-grained, siliceous, sandstone; usually buff or greyish, but occasionally of brownish, hue. Rough spheroidal concretions of the blue carbonate of copper are scattered through it at unequal intervals; but they are too small and too few to stimulate pursuit.

(*b.*) The succeeding bed is a thin one of mottled tenaceous clay, here and there slightly impregnated with granular quartz, but entirely destitute of ore.

(*c.*) A great thickness of sandstone overlies the clay, but only a portion of it is metalliferous. Quartz—often tinged, more or less, with brown iron-ore, is always its chief ingredient; but nests of the sulphate of barytes occur in a few, and lignite—as well of earthy as of fibrous structure—abounds in many of the lower layers. Narrow, unconnected, *floors* of quartzose conglomerate overlie all the richer deposits. Even within

* In 1840 the Magnetic declination near Bilbao was about 22° West. Quetelet, *Phil. Trans.*, cxxxix. (1849) p. 208. Sabine, *Ibid, Pl. XIV.*

short distances the metalliferous portions vary much in thickness; for in the *Borriga* * mine they range from fifteen to nearly forty, and average about twenty-five, feet; but at the *San Juan*,* directly east, they scarcely exceed ten; and in the *Expectativa*,* immediately west, they are even thinner. In this part of the series horizontal *partings* or joints prevail.

Small isolated bodies of iron and copper pyrites have been discovered at *Expectativa*, little *pockets* of earthy black copper-ore at *Borriga*, and thin lines of vitreous copper at *San Juan;* whilst the blue carbonate of copper abounds throughout the district, and malachite is yet more plentiful.† At *Borriga*, however, the richest of the carbonates have been obtained near several shallow horizontal joints, between, and, for short distances, on either side of which the sandstone is more ferruginous than elsewhere.

In the hill-side, about forty fathoms below *San Juan*, an ancient drift extends near seventy fathoms towards the south; but—notwithstanding copper is precipitable

* Some fifteen years ago a Spanish mine-owner brought with him to this country about a ton of rich copper-ore; representing it as the produce of—*San Juan* and *Expectativa*—mines which he was anxious to sell. So large and rich a sample, naturally attracted attention; and a Surveyor, of some experience, was forthwith dispatched to examine the properties. He saw, at once, that the specimens, shewn him before his departure, differed materially from the ore afforded by the mines offered for sale, but remarked that they closely resembled that of—the *Borriga*—an adjoining mine, wrought under English superintendence. And ascertained that,—of the carbonates of copper exhibited in London,—the Spaniard had culled some five hundred-weight from the yield of his own mines, and had bought the other fifteen hundred of his neighbours.

† "Copper-ore has been found, and works have been opened in the New Red Sandstone near Pradoe. * * * Specimens of the rock, indicate the dissemination of the green carbonates, in minute quantities through the mass of sandstone."—Murchison, *Silurian System*, pp. 39, 297.

from the water accumulated in it—all traces of ore cease at some distance from the *end.*

As the metalliferous mass was so thick and so slightly

At *Eardiston,* near West Felton in Shropshire, portions of extensive ancient mine-works in the New Red Sandstone, have been, of late years, wrought for nearly eighty fathoms in length and sixteen in depth.

The rocks consist, in great measure of granular quartz, and—when it is unmixed—they are generally white; for the most part, however, ferruginous clay is also a constituent, and then yellow, brick-red, and brownish hues prevail. Minute proportions of calcareous matter occur at intervals.

The metalliferous bed bears 12°—18° E. of N.—W. of S.,[a] dips 30°—40° W., and—averaging some four feet—ranges from a few inches to about five feet, in width. Although bounded in many places by *(smooth walls)* joints, it just as often shades gradually into the adjoining rock; generally affecting, however, three subordinate layers, *slices,* or *combs* in most, but four in a few, parts of its course. It consists, in great measure, of granular quartz, but—near the surface especially—earthy brown iron-ore is also a large ingredient. Malachite—though less abundant—occurs in considerable quantities, and grains of a grey copper-ore appear at intervals. The following columns give some idea of their disposition in different parts of the mine.

Layers.	East.	Middle of the Mine.	West.
Lower ..	(1) Sandstone, heavily charged with malachite.	(1) Sandstone, spotted with malachite.	(1) Feruginous sandstone, sprinkled with malachite and grey copper-ore.
Middle..	(2) Sandstone, spotted with malachite.	(2) Ferruginous sandstone, thinly sprinkled with malachite.	(2) Sandstone, enclosing grains of malachite. (3) Ferruginous sandstone.
Upper ..	(3) Idem.	(3) Sandstone, densely charged with malachite.	(4) Ferruginous sandstone, largely mixed with malachite and spotted with grey copper-ore.

Although small *(vughs)* cavities in the ferruginous sandstone are often lined with mamillary malachite, the middle is ever the poorest part of the formation.

A thin, highly-inclined, layer of tough blue clay unites with the metalliferous bed at about sixteen fathoms from the surface; when every trace of ore at once disappears.

A narrow *cross-vein* of ferruginous clay traverses, but does not *(heave)* displace, the copper-bearing band; for some distance south of the intersection, however, the ore is less plentiful than elsewhere.

"The ores obtained during 1841—3 yielded from 0·08 to 0·25 their weight of metal, and realized altogether about £2,500."

Frederick Bankart, Esq. (of Langley Lodge, Herts), MSS.

"The existence of copper ores in rocks of the same age is well known. * * * [They] occur in the south-eastern face of the Peckforton Hills * * * in strings

a In 1838 the Magnetic declination was about 25° 30′ West.—Ross, *Phil. Trans.*, cxxxix., 1849, p. 208. Sabine, *Ibid, Pl.* xiv.

inclined, it was more convenient to quarry, than to mine, it. The rock was, therefore, scarped for nearly twenty fathoms in height; notwithstanding the upper, and by far the larger, part was unproductive.

(*d.*) The surrounding hills are capped with greyish-white limestone.

(*e.*) At *Borriga* and *Expectativa* notable quantities of petroleum have, from time to time, been obtained.*

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and veins associated with dislocations more or less transverse to the main direction of the red sandstone, the only exception * * * being in Stanner Hill, where certain poor mineral veins appear to range from south-west to north-east, or parallel to the ridge.

"The rocks of Hawkstone [are] analogous to those of Alderley Edge, in containing traces of copper ore and ferruginous oxide of cobalt, together with concretions and veins of sulphate of barytes."

Murchison, *Silurian System*, pp. 39, 298.

"The metalliferous formation, wrought in the New Red Sandstone at *Alderley Edge*, bears about S.E. and N.W., and is for the most part nearly vertical, though in the bottom of the mine it slopes slightly towards the S.W. * * *.

"The vein-stone-as in all other metalliferous deposits-bears a close resemblance to the adjoining rock. The ores—chiefly the green, but now and then the blue, carbonate of copper—are thinly diffused, and accompanied occasionally by earthy cobalt ore. * * * The proportion of copper obtained from the ore scarcely exceeds $2\frac{1}{2}$ per cent."—Higgs, *Cornwall Geol. Trans.*, vii. p. 325. (Abridged.)

* James Mason, Esq. (Baron de Pomeron, Knight Commander of the Order of Christ), MSS.

ON THE MINES OF *CHALANCHES D'ALLEMONT*, IN FRANCE.

The small well-cultivated plain below Bourg d'Oisans in the department of the Isère is traversed from S.E. to N.W. by the Romanche; and from E. to W. by the Olle, one of its tributaries. Immediately N. of their union, the mountains of Chalanches—portions of the Alpine chain—rise some (2,050 *mètres*) 6,720 feet above the table-land, or (2,750 *mètres*) 9,020 feet above the sea.*

The middle and upper parts of the range consist of granitic gneiss, in which felspar and hornblende are always large ingredients; sometimes, however, quartz and calcareous spar abound, epidote occurs at intervals, and talc, chlorite, or mica is not uncommon.† The rock, though now and then fine-grained—is mostly

* De Thury, *Journal des Mines*, xx. p. 42. Gueymard, *Sur la Minéralogie, la Géologie, et la Métallurgie du département de l'Isère* p. 217.

† "La montagne des Chalanches * * * est formée de gneiss et de hornblende. * * * Les bancs de ces rochers sont en général inclinés au couchant sous un angle plus ou moins ouvert, et ils renferment * * * plusieurs couches de pierre à chaux blanche, qui doivent avoir été formées en même temps que le gneiss; car ces deux substances se perdent et se confondent insensiblement l'une dans l'autre."—SCHREIBER, *Journal de Physique*, XXIV. p. 380.

De Bournon, *Ibid*, pp. 202, 430—5.

"La montagne des Chalanches est primitive et composée de roches, dont les unes sont à base simple, et les autres à base mélangée. Ces dernières sont les plus nombreuses; ce sont elles qui constituent particulièrement la masse de la montagne. La majeure partie des filons connus se trouve dans une roche quartzeuse micacée, dont les couches inclinent généralement au Sud-Ouest, sous un angle qui varie très-fréquemment. La manière d'être des roches, les uns à l'égard des autres, est assez constante. Le granite fait la base de la montagne; il est feuilleté· Souvent il participe de la nature du gneis, quelquefois de celle des roches amphiboliques, et souvent des unes des autres en même-tems. Les

coarse and of porphyritic structure; but, at short distances from the *lodes*, the small crystalline masses of felspar and hornblende,—imbedded in the other constituents,—are generally of indeterminate outline and often graduate into the surrounding basis; whilst

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gneis et les roches micacées sont aussi variées par le grain et la contexture de leur pâte, que par la différence de leurs élémens constituans. Ces roches alternent fréquemment avec les roches amphiboliques; souvent elles sont mélangées ensemble, et plus souvent encore leur association se présente avec tous les caractères d'un granite, dans lequel le mica serait peu abondant. Dans quelques endroits, le gneis contient des pyrites de fer sulfuré, et par fois des parties calcaires, * * * . La couleur du gneis varie extraordinairement: le gris, le jaune, le vert, le blanc, le noir, etc., sont les teintes les plus communes; mais souvent il a une couleur rouge ou rougeâtre, qui a fait donner aux rochers qu'il constitute le nom de *roches brules*. * * * Vers le haut de la montagne, on voit des roches quartzeuses et amphiboliques en couches contournées, et repliées sur elles-mêmes; quelquefois les plis et replis sont très-multipliés dans les mêmes masses. La cîme de la montagne est de roche schisteuse amphibolique veinée de quartz."—De Thury, *Journal des Mines*, xx. pp. 43—5.

"La montagne des Chalanches est formée de gneiss, souvent amphibolique, avec des couches subordonnées de diabase. Les gneiss sont variés à l'infini."

Gueymard, *Sur la Minéralogie, la Géologie, et la Métallurgie, du département de l'Isère*, p. 120.

"Le gneiss prend quelquefois une texture granitöide sans perdre entièrement sa disposition schisteuse."—

De Beaumont, *Annales des Mines*, 3me Série, v. p. 10.

"La diabase des Chalanches est formée, en majeure partie, d'amphibole hornblende, d'un vert très foncé, éclatante, largement lamelleuse. Dans certaines parties de la roche, de grands cristaux d'amphibole sont enchevêtrés avec des cristaux plus petits, de manière à ne laisser au feldspath que très peu d'espace à remplir. Dans d'autres échantillons, au contraire, les cristaux d'amphibole sont nets, presque isolés les uns des autres, et le feldspath en cristaux trés petits en remplit les interstices; quelquefois les cristaux d'amphibole les mieux développés sont placés à peu près parallèlement les uns aux autres, et par suite la cassure de la roche présente, comme celle du granite graphique, l'aspect d'une mosäique assez régulière. * * *

"Le feldspath est toujours en cristaux de petite dimension, d'un blanc de lait, à peine translucide, avec l'éclat nacré un peu gras qui caractérise l'andésite. Il est difficile de le séparer complétement soit de l'amphibole, soit de l'epidote qui lui est toujours associée et intimement mélangée. * * *

"Cette épidote est vitreuse, transparente, d'un jaune verdâtre pâle; elle est en aiguilles déliées, groupées confusément avec les lames du feldspath."

Lory, *Bulletin de la Société Géologique de France*, 2e Série, vii. pp. 540–4.

elsewhere they form distinct and perfect crystals.* The beds present considerable undulations; but, on the whole, their direction is about meridional, and they dip towards the west.

Near Allemont, on the east, the gneiss is overlaid by hornblendic slates.†

The discovery of native-silver, by a goatherd whilst searching for a strayed kid, in 1767,‡ induced opera-

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* "Both in granite, and *elvan*, a well-defined porphyritic structure is a most unpromising character; whilst a gradual blending of the included crystals with the basis of the rock, is, in both cases, considered an encouraging appearance."
HENWOOD, *Cornwall Geol. Trans.*, v. 225.

† "Au pied de la montagne des Chalanches, près du Village d'Allemont, on trouve aussi des petites côtes de schiste et d'ardoise calcaire."
SCHREIBER, *Journal de Physique*, XXIV. p. 388.

De Bournon, *Ibid*, pp. 203, 431.

"Au tiers de la hauteur * * * on voit trois couches de *calcaire* primitif qui alternent avec des roches granitiques, micacées et amphiboliques. Ces couches sont inclinées de 60° à l'Ouest; elles sont dirigées du Nord au Sud. A peu de distance de là, on trouve des roches feld-spathiques blanches, contenant des grenats, au-dessous des roches granitiques avec des tourmalines, et enfin en descendant à Allemont, la juste position du calcaire secondaire sur les roches primitives."—DE THURY, *Journal des Mines*, XX. p. 45.

"La gorge occidental appelée le *Clos du Chevalier*, présente un sujet d'étude intéressant, l'existence d'une couche de houille sèche, dite anthracite, entre les couches d'argile schisteuse à empreintes végétales, deposée sur une brèche granitöides; celle-ci recouvre immédiatement les roches primitives de gneis ou amphibole, qui recèlent les filons d'argent."—*Ibid*, p. 48.

De Beaumont, *Bulletin de la Société Géologique de France*, 2e Série, XII. p. 584.

"Vers le bas de la montagne, près de l'Eau-d'Olle, les roches sont de schistes talqueux et micacés, avec des grenats en très-grande quantité. Ces terrains sont recouverts sur les flancs inférieurs par les calcaires ardoises du lias, et au-dessus des exploitations des Chalanches par un lambeau de grès à anthracite."
GUEYMARD, *Sur la Minéralogie, la Géologie, et la Métallurgie de l'Isère*, p. 121.

"Les diorites schistöides paraissent aussi en liaison bien plus intime avec les terrains de cristallisation, et appartenir à la même formation que les gneiss avec lesquels ils alternent."—LORY, *Bulletin de la Société Géologique de France*, 2e Serie, VII. p. 540.

‡ The discovery is stated
by M. Schreiber, Resident Director of the Mines (*Journal de Physique*, XXIV. p. 381), to have been made in 1767;
„ M. Alexandre Brongniart (*Traite de Mineralogie*, II. p 260), „ 1763;
& „ M. Gueymard .... (*La Mineralogie, &c. de l'Isere*, p. 122), „ 1768.

tions, which in process of time have extended

		feet.	
from (642 toises * or 1251 mètres)	4107 to (1514 mètres)	4967 †	above the plain,
or (............ 1951 ‡ „)	6401 „ (2214 „)	7264 ‡	„ sea;

and necessitated the erection of dwellings and workshops on the mountain-side.

Amongst the principal *lodes* wrought at *Chalanches*§ are—

the *Freiddan*,	which bears	25° S. of E.—N. of W.,‖	and dips towards the	S.W.;—
„ *Cobalt*,	„	30° W. of N.—E. of S.,	„	N.E.;—
„ *Siméon*,	„	35° W. of N.—E. of S.,	„	N.W.;—
„ *Prince*,	„	20° W. of N.—E. of S., 20° N. of E.—S. of W.,	„ „	E.;— N.;—
„ *Hercule*,	„	20° W. of N.—E. of S.,	„	E.;—
„ *Pirou*,	„	25° E. of N.—W. of S.,	„	S.E. & N.W.: and
the *Ste. Héléne*,	„	20° W. of N.—E. of S.,	„	W.;

beside a much greater number of smaller veins.

In one part of its course, the *Prince lode* assumes—and thenceforward maintains—a bearing at about a right-angle to its previous direction *(Table XVI.)* ¶

(1.) Of the eight several directions—all, more or less, oblique to the Alpine chain—

6 (or 0·750) range from S. of E.—N. of W., whilst
2 („ 0·250) „ N. of E.—S. of W.,

the mean strike being about 33° S. of E.—N. of W.

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* Schreiber, *Journal de Physique*, xxiv. p. 381.

† De Thury, *Journal des Mines*, xx. p. 45.

‡ Gueymard, *La Minéralogie, la Géologie, et la Métallurgie de l'Isère*, p. 207. *Ante*, p. 517, Note*.

§ " M. Schreiber a laissé, non-seulement des plans minutieusement exacts de ses travaux souterrains, mais encore des notes, états et mentions de la nature et de la qualitié des minerais qu'il rencontrait dans ses fouilles."—Lefebvre, *Notice sur les minerais et usines des Chalanches d'Allemont* (1853), p. 5.

‖ In 1840 the magnetic declination at Bourg d'Oisans was about 20°.
Hansteen, *Phil. Trans.*, cxxxix. (1849) p. 208. Sabine, *Ibid, Pl. XIV.*

¶ " Whether this deflection is occasioned by the interference of another vein, the works in the neighbourhood are insufficient to show."
Captain Thomas Blamey, Manager of the Mines, MSS.

(2.) The dip—often less than 50°, but seldom more than 70°—is, on the whole, much lower than that of productive *lodes* in general.

Of the eight series

4 (or 0·500) are towards the N. & E.;—
2 („ 0·250) „ N. & W;—
1 („ 0·125) is towards the S. & W.; and
1 („ 0·125) dips towards opposite points in different parts of its course.

(3.) Although the *lodes* generally measure but a few inches, and average less than a foot, they are, now and then, for short distances, as much as two feet and a half, in width.

(4.) The principal earthy ingredients of the *lodes*, are—as in other districts,—much the same as those of the adjoining rocks; but they affect different proportions, and are mixed with other substances.* Thus

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* "Les gîtes de minerai de la montagne des Chalanches sont de vrais filons et des couches minérales, mais de peu d'êtendue. * * * On n'en connoît que deux ou trois qui aient eu 40 à 50 toises (42·6 to 53·2 fathoms) de longueur sur 30 (about 32 fathoms) de profondeur et de largeur; et c'est ce qui a fait dire à plusieurs Minéralogistes, que le minerai ne se trouvoit aux Chalanches que par nids et par rognons; ce qui pouvoit d'autant plus s'accréditer, que l'on trouve assez souvent à la surface de la montagne des peitites veines qui n'ont que quelques toises de longueur ct de profondeur, qui fournissent la mine la plus riche et de l'argent natif, et qui tarissent avant qu'on soit parvenu à en ramasser quelques quintaux.

"Vers l'intérieur de la montagne, les filons et couches minérales ont un peu plus de suite, ils n'y sont pas moins riches que vers le jour, mais ils sont moins nombreux. * * *

"Les filons et couches disparoissent sous differentes circonstances; ou leur épaisseur diminue jusqu'à ce qu'il n'en reste plus de trace dans le rocher; * * * ou ils se perdent dans un rocher brisé et fracassé.

"Les gîtes de minérais d'argent * * * se trouvent tous dans un district qui à environ 300 toises (some 320 fathoms) de longueur et 250 toises (266·2 fathoms) de largeur. Quoique ces gîtes soient assez près les uns des autres, il

felspar, quartz, and calcareous-spar always abound;

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n'y en a cependant que peu qui se joignent ou se croisent; ils sont, pour la plupart, séparés les uns des autres, et pour ainsi dire isolés dans le rocher. On n'a point trouvé jusqu'à présent de filons nobles plus avant dans la montagne que 100 toises en ligne horizontale depuis le jour.

"Rien de si bizarre et de si irrégulier que les filons et couches minérales des Chalanches dans leur direction et leur inclinaison. Il est très-rare qu'un filon conserve la même direction et la même inclinaison dans une étendue de 6 à 8 toises (6·5 to 8·5 fathoms); ils se jettent tantôt d'un côté, tantôt de l'autre. Les couches minérales y sont un peu plus constantes que les filons, parce qu'elles suivent les bancs de rocher qui les renferment, au lieu que les filons les coupent. Il y a autant de différences dans la direction des filons des Chalanches, qu'il y a de divisions sur la boussole du mineur, et leur inclinaison varie depuis 5° jusqu'à 70°. Cependant les couches minérales qui se maintiennent le mieux, sont celles qui ont leur direction du sud au nord, et dont l'inclinaison est occidentale; et les filons qui se soutiennent le plus sont ceux qui ont la même direction, mais dont l'inclinaison est orientale.

"L'ochre martiale constitue la majeure partie les filons d'Allemont, qui ont depuis 1 jusqu'à 12 pouces d'epaisseur. * * * Une moindre partie de nos filons est composée de spath calcaire; et * * * dans l'intérieur des Chalanches, et principalement dans le voisinage des filons, le gneiss est entremêlé de parties calcaires; propriété que le gneiss n'a pas à la superficie de la montagne.

"Le schorl vert [? epidote] sert aussi quelquefois de gangue aux filons riches en minérai d'argent; on trouve même de temps à autre ce métal natif dans le schorl.

"Enfin, l'asbeste et l'amiante sont la dernière variété de nos gangues.

"Les filons qui consistent en un terre argileuse grisâtre, sont ceux qui encouragent le moins le mineur.

"Si la direction, l'inclinaison et l'étendue des filons sont bizarres, leurs produits ne le sont pas moins. Il arrive assez souvent, en les poursuivant, qu'on découvre des rognons extrêmement riches, et qu'à 1 pied plus loin il n'y a que de la mine d'une médiocre valeur. Un essai d'un filon nouvellement découvert contenant 60 à 80 marcs d'argent au quintal [0·300 to 0·400 its weight] ne donne pas plus d'espérance que s'il n'en contenoit qu'un seul marc [0·005]; car on sait, par l'expérience journalière, que ces filons ne se maintiennent pas dans l'étendue d'une toise dans le même état. * * * Les productions des filons des Chalanches sont très-variées. J'ai déjà observé que j'ai découvert un indice d'or dans une pyrite cuivreuse. La majeure partie du minérai d'argent consiste en une terre ferrugineuse.

"L'argent se trouve, natif en filets contournés, et en lames, dans différentes gangues. Le spath calcaire en est souvent pénétré, et plus souvent l'argent vierge y est niché dans les cavités avec un *mulm* noir ou mine d'argent noire en poussière. Quelques-uns des échantillons de spath calcaire pénétrés d'argent natif, étoient accompagnés de cinabre. * * * Une seule fois, j'ai découvert dans cette exploitation de la mine d'argent cornée cubique, couleur de foie dans

hornblende is, perhaps, less plentiful; but chlorite,

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un mine de cobalt terreuse, où elle étoit accompagnée de parcelles de mines d'argent rouge et entourrée d'argent natif.

"Les mines d'argent vitreuses, rouges et grises n'y abondent pas. * * *

"La mine d'argent rouge est quelquefois renfermée dans de l'asbeste, et la mine d'argent grise dans du schorl vert. Cette dernière contient depuis 20 jusqu'à 40 marcs d'argent au quintal (0·010 to 0.020). En général les crystallisations de minérai et des métaux sont extrêmement rares aux Chalanches.

"Il ne s'y trouve que peu d'échantillons de mine de cuivre jaune, et de mine de plomb en galène; la dernière donne un marc et quelques onces d'argent au quintal.

"La mine d'Allemont jouit d'une grande réputation, à cause de ses beaux morceaux de mine de cobalt terreuse, dont quelques espèces sont connues sous le nom de mine d'argent merde-d'oie. La mine de cobalt ne s'y présente qu' accidentellement et par échantillons: jamais elle ne constitue des filons un peu suivis; elle s'y trouve ordinairement parmi le minèrai ferrugineux, quand il est bien riche en argent. * * * La mine de cobalt grise arsenicale est la seule de nos mines qui soit pauvre en argent; mais elle est encore plus rare que les autres espèces. * * * Sur *cent quintaux* de mine d'argent qu'on y extrait, il y a *à peine vingt livres* (0·002) de cobalt de l'espèce dont je viens de parler. * * *

"On a trouvé aux Chalanches presque tontes les espèces de mines de cobalt. La plus remarquable est celle que l'on connoît sous le nom de mine de cobalt noire ou vitreuse; elle est souvent traversée par des lames d'argent, et contient 20 jusqu'à 80 marcs (0·100 to 0·400) de ce metal au quintal.

"Les autres espèces de mine de cobalt terreuse sont plus ou moins riches, et remplies de filets d'argent capillaires; il y en a même qui donnent à l'essai 72 marcs (0·360) per quintal. J'ai aussi trouvé du cobalt gris noirâtre avec des parcelles de mine d'argent rouge dans une gangue de schorl vert; et dans le Kupfer-Nickel, j'ai trouvé un indice d'or. * * *

SCHREIBER, *Journal de Physique*, XXIV. pp. 381—7.

"Les minerais des Chalanches sont disposés en filons, en couches et en rognons.

Les filons varient à l'infini; ils n'ont aucune manière d'être uniforme: leur puissance, leur direction et leur inclinaison, éprouvent des variations continuelles, et sont sujettes à un grand nombre d'accidens. Ces filons sont généralement placés les uns au-dessus des autres; ils sont voisins, très-rapprochés; ils se croisent en tous sens; ils ne conservent ni direction, ni inclinaison, ils prennent fréquemment une marche opposée à celle qu'ils tenaient précédemment; enfin, ils se réunissent, ils marchent quelque tems ensemble; ils se séparent pour se réunir de nouveau ou pour disaparaître entièrement, et avec des circonstances très-differentés. La richesse des filons ne se maintient pas mieux que leur manière d'étre. On voit souvent des filons qui donnent 20 et 25 d'argent pour

talc, mica, epidote, and asbestus occur, here and there, in smaller quantities.

Calcareous-spar, chlorite, asbestus, and epidote have been found more or less *kindly* vein-stones; but earthy

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100 de minerai, ne presenter, a quelques décimètres de distance, que des gangues stériles.

"Les couches de minerai sont plus rares que les filons; elles n'ont que peu de suite; elles éprouvent les mêmes accidens. Leur richesse, leur direction, leur inclinaison, leur puissance, etc., varient continuellement; elles sont sans cesse coupées, rejetées, étranglées et interrompues par les filons; enfin, * * * je suis porté à les regarder plutôt comme des filons horizontaux, que comme des couches véritables.

"Les rognons sont moins nombreux que les filons, * * *.

"La gangue est encore plus variée que la manière d'être; le plus communément c'est la chaux carbonatée; elle se trouve pure, mélangée, associée, cristallisée, informe, etc. Quelquefois, c'est la chaux sulfatée; en d'autres endroits, c'est l'asbeste-amiante; souvent, c'est le quartz hyalin, * * * par fois la gangue est argilo-calcaire: ici c'est le talc-clorite pulvérulent vert ou brun; plus loin le même est en masse, et contient de l'argent natif. Souvent c'est l'épidote en masse ou cristallisé.

"Parmi les gangues métalliques, nous trouvons l'oxyde de cobalt terreux et vitreaux, les cobalts arseniaté, arsenical, gris, et tout plus ou moins argentifères.

"Les nickels arsenical et carbonaté font fréquemment l'office de gangue. Le premier est même, par fois puissamment riche en argent. L'arsenic se trouve également dans les minerais argentifères.

"L'antimoine s'est trouvé dans les états natif, sulfuré, oxydé et hydrosulfuré.

"Le cuivre, qui est très-abondant dans les filons, se trouve en différens états; il est pyriteux, sulfuré, carbonaté vert et bleu. Le cuivre gris se trouve très-fréquemment dans l'asbeste, et toujours il est très-riche en argent.

"Le fer et le manganèse, l'un et l'autre oxydés, sont généralement répandus dans les filons; le dernier présente même une des plus riches gangues en argent.

"Le plomb se trouve à l'état sulfuré, et quelquefois à l'état phosphaté."

Héricart de Thury, *Journal des Mines*, xx. pp. 45—8.

"Les minerais d'argent de la montagne dont on vient de rappeler la constitution géologique, sont disposés en veines, rognons, amas et filons, toujours irréguliers et de peu d'étendue. Ces gîtes sont très-rapprochés les uns des autres, souvent parallèles, puis se coupant bientôt sous toutes sortes d'angles, changeant à chaque instant de puissance, de direction, d'inclinaison et de richesse. Ainsi on trouve l'argent massif et natif, puis des minerais rendant 50 pour cent de ce métal, et quelques instans après les trésors disparraissent et sont remplacés par des gangues stérils. Les changemens brusques s'opèrent souvent dans moins de trois pieds de longueur de galerie, ce qui a toujours aussi rendu l'exploitation

brown iron-ore—whether in small isolated masses and short, thin, veins, or mixed with other substances—is, by far, the most congenial matrix to ores of greater value.

The produce has consisted principally of native silver,* and of the vitreous,† earthy black,‡ and red § ores of silver; from time to time, however, small quantities of horn-silver ‖ have been obtained. These

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irrégulière dans ses produits. On conçoit effectivement que l'atelier peut rester six mois, un an et plus sans donner de l'argent, puis dans vingt-quatre heures on trouve largement de la matière, non-seulement pour payer tous les frais passés, mais encore pour faire face à de semblables chances.

"Les Chalanches ont produit:—1.° L'argent natif; 2.° l'argent antimonial; 3.° l'argent antimonié sulfuré; 4.° l'argent sulfuré; 5.° l'argent muriaté. * * * Chaux carbonatée, chaux carbonatée ferro-manganésifère, chaux carbonatée manganésifère, chaux sulfatée, baryte sulfatée, quartz, quartz jaspe, grenat, feldspath, tourmaline, axinite, épidote, amphibole, peridot, mica, asbeste, souffre, anthracite, or, mercure, plomb, cuivre, nickel, fer, manganèse, zinc, cobalt, antimoine, arsenic, et titane siliceo calcaire."

GUEYMARD, *Sur la Minéralogie, la Géologie, et la Métallurgie de l'Isère*, pp. 121—2.

* Schreiber, *Journal de Physique*, XXIV. p. 385. De Bournon, *Ibid*, p. 203. Haüy, *Traité de Minéralogie*, III. p. 387. De Thury, *Journal des Mines*, XX. p. 83. Brochant, *Traité Elémentaire de Minéralogie*, II. p. 118. Alex. Brongniart, *Ibid*, II. pp. 249, 260. Mohs, *Treatise on Mineralogy*, II. p. 436. Gueymard, *La Minéralogie*, &c., *de l'Isère*, p. 121—2. Lory, *Description d'une collection de Minéraux formee par M. H Heuland*, II. pp. 324,—5,—6.

† Schreiber, *Journal de Physique*, XXIV. p. 385. De Thury, *Journal des Mines*, XX. p. 84. Mohs, *Treatise on Mineralogy*, III. p. 12. Gueymard, *La Minéralogie* &c., *de l'Isère*, p. 112.

‡ Schreiber, *Journal de Physique*, XXIV. p. 385. Brochant, *Traité Elémentaire de Minéralogie*, II. p. 113. Phillips, *Mineralogy* (Third Edit.) p. 289. Mohs, *Treatise on Mineralogy*, II. p. 436. *Table XVI.*

§ Schreiber, *Journal de Physique*, XXIV. p. 385. De Bournon, *Ibid*, p. 204. De Thury, *Journal des Mines*, XX. p. 85. Brochant, *Traité Elémentaire de Minéralogie*, II. p. 146. Mohs, *Treatise on Mineralogy*, III. p. 42. Gueymard, *La Minéralogie*, &c., *de l'Isère*, p. 122.

‖ Schreiber, *Journal de Physique*, XXIV. p. 385. De Thury, *Journal des Mines*, XX. p. 84. Alex. Brongniart, *Traité Elémentaire de Minéralogie*, II. p. 257. Gueymard, *La Minéralogie*, &c., *de l'Isère*, p. 122.

are—often together, but sometimes separately—imbedded in, or mixed and invested with, earthy cobalt * and cobalt bloom ; † and all—with smaller proportions of arsenical cobalt,‡ arsenical nickel,§ and the arseniate of nickel,‖—are enveloped in the ordinary vein-stone. Various ores of antimony, lead, and copper are also thinly scattered through the same matrix, but, hitherto, the deepest have been found the least productive parts of the *lodes.*¶

(5.) The *Brisée (cross-) vein*—differing in direction from some of the *lodes* less than they differ from one another—bears 35° N. of E.—S. of W.; its dip towards the south — like the mean of *cross-veins* in

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* Schreiber, *Journal de Physique,* XXIV. p. 386. De Bournon, *Ibid,* p. 204. Haüy, *Traité de Minéralogie,* IV. p. 220. De Thury, *Journal des Mines,* XX. p. 83. Alex. Brongniart, *Traité Elémentaire de Minéralogie,* II. p. 120. Levy, *Description d'une collection de Minéraux,* III. pp. 247.—9. *Table XVI.*

† Schreiber, *Journal de Physique,* XXIV. p. 389. De Thury, *Journal des Mines,* XX. pp. 83, 97. Berthier, *Annales des Mines,* IV. p. 472. Levy, *Description d'une collection de Minéraux,* III. p. 262. *Table XVI.*

‡ Schreiber, *Journal de Physique,* XXIV. p. 386. De Bournon, *Ibid,* p. 212. Haüy, *Traité de Minéralogie,* IV. p. 203. De Thury, *Journal des Mines,* XX. pp. 83, 95. Alex. Brongniart, *Traité Elémentaire de Minéralogie,* II. p. 116. Berthier, *Annales des Mines,* IV. p. 472. Levy, *Description d'une collection de Minéraux,* III. pp. 247,—9,—51.

‡ Schreiber, *Journal de Physique,* XXIV. p. 387. De Bournon, *Ibid,* p. 212. Haüy, III. p. 515. Brochant, *Traité Elémentaire, de Minéralogie,* II. p. 410. De Thury, *Journal des Mines,* XX. pp. 83, 90. Alex. Brongniart, *Traité Elémentaire de Minéralogie,* II. p. 209. Berthier, *Annales des Mines,* IV. pp. 467,—70,—4. Mohs, *Treatise on Mineralogy,* II. p. 448. Levy, *Description d'une collection de Minéraux,* III. pp. 251,—69. Delesse, *Annales des Mines,* 4me Série, XIV. p. 461.

§ De Thury, *Journal des Mines,* XX. p. 90. Phillips, *Mineralogy* (3rd Edit.), p. 284. Mohs, *Treatise on Mineralogy,* II. p. 448. Berthier, *Annales des Mines,* IV. p. 472. Levy, *Description d'une collection de Minéraux,* III. p. 270. *Table XVI.*

¶ " Les filons furent beaucoup plus riches vers la surface que dans la pro-

Cornwall *—is at a much higher angle than the dip of any *lode* in the vicinity; and—like the Cornish *cross-veins* †—it is wider than the widest *lode* in the neighbourhood. It consists wholly of gneiss; ‡ softer, perhaps, than the adjoining *(Country)* rock, but of much the same composition and structure.

The *cross-vein* intersects the *Hercule lode*, and displaces *(heaves)* it about twelve fathoms *(R.,G.A.)* towards the right-hand, and to the side of the greater angle; but it is not seen in contact with any other *lode*.

In the hornblendic slates which succeed the gneiss, near Allemont on the south-east,§ unsuccessful trial has been made of a *lode*, which—bears 35° N. of E.–S. of W.,—dips towards the north,—measures some eighteen inches in width,—and contains disintegrated slate and quartz, sprinkled with earthy black manganese and specular iron.

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fondeur."—ALEX. BRONGNIART, *Traité Elémentaire de Minéralogie*, II. p. 260.

* Thomas, *Survey of the Mining District between Chasewater and Camborne*, p. 21. Fox, *Reports of the Royal Cornwall Polytechnic Society*, IV. p. 84. Henwood, *Cornwall Geol. Trans.*, V. pp. 247,—50,—77,—9, *Tables CI.,—III.,—IV.,—VI.*, *Ante*, p. 410, Note *.

† Henwood *Cornwall Geol. Trans.*, V. *Tables CI.,—IV.*, *Ante*, p. 410, Note *.

‡ "Les filons * * * sont coupès par une espèce de gros filons sauvages, composés de terre argilleuse et de morceaux arrondis de gneiss."

SCREIBER, *Journal de Physique* XXIV. p. 382.

§ In 1853 a resident practitioner with the divining *(dowsing)*-rod *(la baguette)*, offered an English party his professional aid, in this part of the district."

Agricola, *De Re Metallica*, pp. 26—8, *Fig.* 1. Borlase, *Natural History*, p. 165. Pryce, *Mineralogia Cornubiensis*, pp. 113—24. De la Chabeaussière, *Journal de Physique*, XXIV. p. 423. Rees, *Cyclopædia*, XXXVII. (VIRGULA *Divina)*. Henwood, *Mining Review*, I. p. 403.

The mines were wrought at such an elevation, and at so great a distance from every habitation, that, even in summer, the workmen seldom visited their families except on Sundays; during several of the winter months, however, frozen snow of miles in extent, and, at intervals, of many feet in thickness, often impeded, and sometimes, for several successive weeks entirely prevented all, communication with their nearest neighbours.*

In spring the steep and ill-made roads are always injured, and sometimes they are destroyed, by frequent avalanches and the general thaw.

It therefore was necessary to collect, at the mines, in summer, all materials, tools, fuel, food, and other things requisite during winter. And in order to avoid unnecessary carriage every utensil was shaped on the plain.†

Of course, such difficulties added materially to the ordinary expense of working.

The mines of Chalanches were wrought, and the ores obtained from them were smelted at Allemont,

from 1767 to 1776 on account of the Government;—
,, 1776 ,, 1792 ,, the Compte de Provence (afterwards Louis XVIII.);
,, 1792 ,, 1808 ,, the Government;

and more recently, at intervals, by various lessees.‡

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* "M. Gueymard states that the higher mountains in Dauphiné are rarely accessible for more than the last ten days of July and the first week or two of August."—Forbes, *Norway and its Glaciers*, p. 257.

In May, 1853, a path to the mines was opened through frozen snow; which, in many places, exceeded seven feet in depth. Yet on a leafless tree, in this dreary region, a cuckoo perched in full song.

† The smiths' fires—like those at *Monlevade* and *Catta Preta* in Brazil—were blown by *water-blasts*. *Ante*, pp. 219—20.

‡ Gueymard, *La Minèralogie*, &c., *de l'Isère*, p. 122—4.

From 1767 to 1803 the quantity of silver extracted amounted to (9,453 *kilogrammes*) 25,326·39 lbs. *Troy*;

which—at £3 : 6 : 3·4 per lb.—realized	(2,098,481 *francs*)	£83,939
whilst the general expenditure was ..	(1,890,896 „)	75,636
In thirty-six years, therefore, the net profit was	(207,585 „)	£ 8,303 *
beside the furnaces, machinery and tools, which — having been provided from the proceeds of the ores—were now valued at	(200,000 „)	£ 8,000 *

Subsequent operations, however, were much less successful.*

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* Gueymard, *La Minéralogie* &c., *de l'Isère*, p. 122—4.

Notice of the *SARK'S HOPE* Mine, Sark

The island of Sark comprehends two unequal tracts of elevated table-land (Great and Little Sark) connected by a high narrow ridge (the Coupée).*

The rocks consist mostly of felspar and hornblende; but actynolite, asbestus, steatite, chlorite, calcareous-spar, and quartz, are, here and there, associated with the other ingredients in imbedded masses or subordinate veins.

In several parts of the island metalliferous deposits have been rather extensively wrought.

(*a*.) At Port ès Sées two *(levels)* galleries were

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* "The little Island of Sercq lies six miles to the east of Guernsey, and is rather more than three miles in length. Its extreme breadth is not more than a mile and a half, and its average breadth not quite a mile. In one part, it is not many yards wide, being nearly divided into two portions, connected only by a high and narrow ridge. * * * It is a table land, having no declivity to the sea at any part, except a small descent at its northern extremity. * * * The eastern side of the land is pretty uniformly about one-third lower than the western. In a general view the western side is of a trap and schistose formation, and the eastern of a granitic."—Mac Culloch, *Geol. Trans.*, o.s., i. p. 13.

"Great Sark and Little Sark form one connected island, the connecting link being a natural causeway, at an elevation of nearly 300 feet above the sea. * * * Great Sark is rather more than two miles in length from north to south, and Little Sark rather less than a mile. The greatest width of land in the principal island is about 3,000 yards. * * * The whole island somewhat resembles the figure 8; but the upper part of the figure should be much larger than the lower part. Its outline is, in fact, a double loop; the two loops of different sizes, connected by a short line. Both Great and Little Sark are table lands, and their elevation above the sea is upwards of 350 feet. The ground sinks towards the south, but is everywhere surrounded by lofty perpendicular cliffs. * * * The predominant rock is syenite, and the principal veins are greenstone, with felspar walls. But besides these, there are numerous veins of asbestiform minerals, of serpentine, and of soft clayey matter, and some strings of quartz. * * * Large quantities of actynolite occur in many parts, and an important vein of serpentine and steatite, with asbestos and talc, has been traced crossing the central part near Port du Moulin."—Ansted, *Channel Islands*, pp. 70,—1, 264.

opened, at different elevations, on a *lode*, which bears 40° E. of N.—W. of S.,* dips N.W. 55°—65°, varies from three to six feet in width, and consists, mostly of disintegrated felspathic and hornblendic matter, arenaceous quartz, and earthy brown iron-ore; wherein hard angular bodies, as well of felspar and hornblende as of massive quartz, and grains both of iron and of copper pyrites are imbedded at intervals.†.

Within about thirty fathoms two other *lodes*—of much the same composition—have been slightly examined. Both bear 24° N. of E.—S. of W., but one has a northerly, whilst the other maintains a southerly, dip; the first, however, measures at least six, whilst the second is scarcely four, feet in width.

The neighbouring rocks abound in felspar, though now and then they contain hornblende also; their structure is usually foliated, and near the *lodes* they are fine-grained and soft, but within short distances, on either side, they become coarse and hard.

(*b.*) The only part of the island in which the miner has yet found encouragement is, however, the immediate vicinity of Port Gouray, near the south-south-western extremity of Little Sark; where the rocks frequently contain much chlorite and calcareous-spar, although felspar and hornblende are always

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* In 1838 the Magnetic declination was about 24° West. Ross, *Phil. Trans.*, cxxxix. p. 208. Sabine, *Ibid, Pl. XIV.*

† At Port és sées a large and most promising *lode*, contains nodules and small strings of iron-pyrites which afford (0·000306 to 0·000460 their weight) from 10 to 15 ounces of silver per ton."

Johnson & Vivian, *Report on the Sark Mines* (1842), p. 2.

their principal constituents.* The southern portions are, somewhat indistinctly, foliated; but towards the north massive structure prevails.†

(1.) Although several *lodes* crop out in the neighbouring cliffs,‡ two only have been examined; viz.—

						feet		
The *Silver-lode*,	which bears	28° E. of N. —W. of S.,	dips	N.W. 66°—85°,	and measures	1·5—11·0	in width;—	
„ *Copper-lode*,	„	N.E.—S.W.,	„	N.W. 70°—75°,	„	2·5—5·0	„	.

(2.) The nearly north-north-easterly and south-south-westerly *(Silver)-lode* maintains a much higher inclination than the contiguous *(Copper)-lode* or the *lodes* at Port ès Sées which range obliquely to it; much as the *cross-veins* of Cornwall and Devon maintain, with respect to the tin and copper *lodes* in their

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* "The southern point of the island is formed of a sienite [in which] the felspar is invariably white."—Mac Culloch, *Geol. Trans.*, o.s., i. p. 16.

"In the western part of the [Sark] the rock at the shallow adit [14 fathoms from the surface] is a decomposing sienite, which continues down to the 10-fathom level [34 fathoms deep]; from thence to the bottom of the mine chlorite appears, which is traversed by numerous small veins of peroxide of iron and carbonate of lime. It is remarkable, however, that in the *cross-cuts* which have been extended a few feet on both sides of the lode, we have invariably found a hard sienitic rock containing an excess of hornblende, but not the least appearance of either iron or lime."—Prince, *Cornwall Geol. Trans.*, vi. p. 103.

"In Little Sark the rocks are somewhat lower than on the larger division of the island, and there is nothing calling for a special remark till we reach the little harbour of Gouray, where, in former times, vessels were moored, bringing stores from Cornwall for the mines adjacent. * * * Veins [which] in large numbers, cross the axis of Sark at right angles, * * * illustrate the fact, that the older fissures, due to early elevation, range east and west, * * * whilst the modern upheavals range rather in a north and south direction."—Ansted, *Channel Islands*, pp. 83, 263,—4.

† "A compact rock, containing masses of felspar, prevails east of the engine-shaft, whereas that in the western part of the mine is foliated."
Prince, *Report on the Sark Mines* (1839), p. 3.

‡ "There are three interesting parallel *lodes*, south of Sark's Hope *lode*."
Vivian, *Report on the Sark Mines* (1838), p, 2.

Table XVII.

respective neighbourhoods;* and as the approximately meridional *lodes* of Keweenaw preserve with regard to the *lodes* of Ontonagon (Lake Superior) to which their directions are either transverse or oblique.†‡

(3.) In average width the *Silver* and the *Copper lodes* are much alike; but the former is frequently of dimensions which the latter never attains.§

(4.) Although the earthy portions of both the *lodes* comprehend several ingredients beside those of the adjoining rocks, various parts display characteristic differences. Felspathic matter is everywhere the prevailing constituent, yet particles, small isolated masses, and short, narrow, strings of calcareous-spar are numerous; granular quartz—if equally plentiful—is less uniformly distributed; veins of coarse jaspar occur at intervals; and spheroidal agatine masses, containing many concentric layers of differently coloured quartz, are imbedded in the other substances. Throughout the north-north-east, and for some forty or fifty fathoms deep, towards the south-south-west, hornblende is a component of the *Silver lode*; but at greater depths it is substituted by chlorite.||

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 247,—50,—77,—79. *Ante*, p. 410, Note*.

† *Ante*, pp. 408,—10.

‡ At *Chalanches*, however, the *lodes* which range mostly between N.N.W.—S.S.E. and N.N.E.—S.S.W. dip at much lower angles than the *(Brisée) cross-vein*, which bears 35° N. of E.—S. of W. *Ante*, p. 527, *Table XVI.*

§ Henwood, *Cornwall Geol. Trans.*, v. pp. 240—5,—75—6, *Tables CI., CIV.*, *Ante*, pp. 409,—10, 532, *Table XVI.*

|| "The matrix of the *lode* consists of fragments of the strata, carbonate of lime, milk, rose, and brown quartz, red, green, and white felspar, and in some places hornstone *(capel)*. * * * Below the 10 fathoms level [34 fathoms from the surface] it is composed of chlorite, carbonate of lime, and felspar, with felspar-clay *(prian)* on the *hanging-wall*."

PRINCE, *Cornwall Geol. Trans.*, VI. pp. 101,—3.

Fig. 30.

SARK'S HOPE MINE, SARK.

Longitudinal section.

Scale 40 fathoms to the inch.

Of the metalliferous contents of both the *lodes* iron-pyrites and earthy brown iron-ore are, by far, the most abundant; * but—as in most other places—the latter

* "The lode, as far down as 40 fathoms below the sea [64 fathoms beneath the surface], contains an abundance of brown earthy iron-ore, * * * with nodulated, radiated, argentiferous, arsenical, auriferous, and white and magnetic iron pyrites *(mundic)*."—Prince, *Cornwall Geol. Trans.*, vi. p. 101.

disappears at little more than fifty fathoms underground.*

(—A.) From the surface to the sea-level—a depth of twenty-four fathoms—the other metallic ingredients of the *Silver-lode* consist, in great measure, of salts; but still deeper they are almost exclusively sulphurets.† At all depths throughout the south-south-west, the ores—as well the salts as the sulphurets—are mostly those of lead; but at corresponding levels towards the north-north-east, they are, almost without exception, those of silver.

The following columns—a brief abstract of *Table XVII.*—show the relative positions of the different ores.

	SOUTH-SOUTH-WEST.	NORTH-NORTH-EAST.
Depths.	*Minerals.*	*Minerals.*
Surface to 24 fathoms	Carbonate of lead; Sulphate of lead; Galena.	Chloride of silver; Earthy black silver-ore.
24 to 64 fathoms	Galena; Antimoniated galena; Super-sulphuret of lead; Sulphato-tricarbonate of lead; Earthy black silver-ore; Vitreous silver; Red silver;	Earthy black silver-ore; Vitreous silver; Copper-pyrites;
		Green carbonate of copper; Blue carbonate of copper.

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* Pryce, *Mineralogia Cornubiensis*, p. 91. Phillips, *Geol. Trans.* I. p. 25; II. p. 117. Weaver, *Ibid*, V. p. 213. Carne, *Cornwall Geol. Trans.*, II. p. 122. Fox, *Report of the Cornwall Polytechnic Society*, IV. p. 85. De la Beche, *Report on the Geology of Cornwall*, &c., p. 326. Henwood, *Cornwall Geol. Trans.* V. p. 206. Ansted, *Quarterly Journal of the Geological Society*, XII. pp. 149,—52; XIII. pp. 243,—6,—9,—51.

† "At the ten fathoms [below the sea] level we found that the bunches of ore which had made and were now making returns in the adits, samples of which produced 37 ounces [0·001133 their weight] of silver to the ton of ore, had altered their mineralized state from the chloride to the sulphuret of silver. At

The proportions of the sulphate of lead and of galena scattered through the carbonate of lead near the surface, and of antimoniated galena, the super-sulphuret of lead, the sulphato-tricarbonate of lead, earthy black silver-ore, silver glance, red silver, and of both the carbonates of copper associated with galena in deeper parts of the *lode* towards the south-south-west; as well as the quantities of earthy black silver-ore mixed with the chloride of silver above the sea-level, and of silver glance and of copper-pyrites intermingled with earthy black silver-ore at greater depths on the north-north-east, are in all cases very small.

Although all the sulphurets of lead are more or less argentiferous, and rich *bunches* of silver-ore have been obtained at intervals,* the metallic minerals are, in general, so thinly scattered through their matrix, that

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the twenty fathoms level the lead, which in the levels above had existed as carbonate, seemed to have altered its state to the sulphuret. At the thirty, nearly the same ore was found, except that a proportion of antimony entered into its composition. At the forty this ore shows a small proportion of ruby silver a sample of which produced [0·009704 its weight] 317 ounces of silver to the ton of ore. A branch of galena, continuous to 15 or 16 fathoms, produced 40 per cent. [0·40] of lead, and 37 ounces [0·001133] of silver per ton of ore. At the fifty west, the lode is divided into two branches, the north branch carried pyrites and silver."

JOHNSON & VIVIAN, *Report on the Sark Mines* (1842), pp. 1—2.

The argentiferous lead "ores produced from 20 to 85 per cent. [0·20—0·85] of lead and from [0·000918—0·003673 their weight] 30 to 120 ounces of silver to the ton of ore."

PRINCE, *Cornwall Geol. Trans.* VI. p. 102; abridged. *Ante*, p. 121, Note.

At Chañarcillo the salts of silver often extend to depths far greater than the bottom of *Sark's Hope;* but they are much more abundant in the shallower than in the deeper parts of the *lodes*. *Ante*, pp. 90—3, 97—100,—11,—16—18,—20—1; *Tables III. IV.*

* A sample of ore obtained some 54 fathoms from the surface yielded at the rate of (0·016225 its weight) 530 Troy ounces of silver per ton.

—from the difficulty of *(dressing)* separating them—they have been sold at low rates.*

The ores of silver prevail in the north-north-eastern—whilst those of lead abound in the south-south-western—parts of the *lode*, and both—conforming, in some measure, to the foliated structure of the adjoining *(Country)* rock—*shoot* † towards the north-north-east. Below a certain point in this line of their endlong dip, therefore, the ores of lead are—like their analogues in the great lead-mines of Brittany—overlaid by those of silver.‡

Notwithstanding the abundance of various ores of silver, neither native-silver,§ nor ore of either

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* Large quantities of the *lode* from shallow parts of the mine,—merely freed from imbedded masses of barren quartz,—were sold at £5 : 10 : 0 per ton.

During thirteen months past the ore has been sold at an average price of £10 per ton.—*Report of the Sark Mining Company* (16th October, 1839), p. 1.

† Tregaskis, *Report of Cornwall Polytechnic Society*, IV. pp. 95—6. Henwood, *Edin. New Phil. Journal*, XXII. p. 157; *Cornwall Geol. Trans.*, V. pp. 41, 54, 87*, 129,—93; VI. p. 145; *Ante*, pp. 122, 215,—16,—59,—63,—4,—9,—70,—3, —82,—3, 319,—23,—6,—82, 437—8.

‡ "Le minerai d'argent occupe la région supèrieure du filon de Huelgoat: il fait suite au minerai de plomb, avec lequel il se confond à la ligne de contact. * * * L'argent se trouve à trois états différents dans le minerai de Huelgoat; à l'état de chloro-bromure, l'argent natif et de sulfure plombo-cuprifère. Les deux premiers de ces minéraux paraissent être plus répandus que le troisième: on les rencontre particulièrement à la crête du massif argentifère, sur tout l'étendue de l'exploitation."

PERNOLLET, *Annales des Mines*, 4me Série, X. p. 420. *Ante*, p. 104.

§ Pryce, *Mineralogia Cornubiensis*, p. 50. Jars, *Voyages Métallurgiques*, II. pp. 101,—21, 380,—3,—93, 402,—96. De Bournon, *Journal de Physique*, XXIV. pp. 204,—11. Schreiber, *Ibid*, p. 385. Kirwan, *Mineralogy*, p. 241. Hitchins, *Phil. Trans.*, XCI. p. 159. Daubuisson, *Des Mines de Freiberg*, III. pp. 58, 210, —11. Alex. Brongniart, *Minéralogie*, II. p. 257. De Thury, *Journal des Mines*, XX. pp. 83—4, 90,—5,—7. Berger, *Geol. Trans.* I. p. 171. De Humboldt, *New Spain*, III. pp. 156,—94, 221,—9,—30. Wm. Phillips, *Geol. Trans.*, II. p. 152; *Mineralogy* (Third Edition), pp. 285,—8. Lysons, *Cornwall*, CCX. Polwhele, *Cornwall*, IV. p, 134. C, S, Gilbert, *Cornwall*, I. p. 218. Carne, *Cornwall Geol.*

cobalt * or nickel,† has ever been observed in the mine.

(—4 b.) The *Copper-lode* differs but little from the *Lead-lode*, either in the nature of its earthy ingredients or in the proportions of the iron-ores it contains. At a depth of forty-four fathoms, however, it is slightly veined and spotted with copper-pyrites.

(5.) The *Lead-lode* intersects, but does not *(heave)* displace, the *Copper-lode*.

Trans., I. pp. 121—4; II. pp. 105,—13,—20. Berthier, *Annales des Mines*, IV. p. 472. Mohs, *Mineralogy*, II. p. 435. Michell, *Manual of Mineralogy*, pp. 20-1. Levy, *Description d'une collection de Mineraux*, II. pp. 321—2,—4—8. Fox, *Report of the Cornwall Polytechnic Society*, IV. p. 92. De la Beche, *Report on the Geology of Cornwall*, &c., p. 613. Braun, *Annales des Mines*, 3me Série, XVIII. pp. 148—50. Daubrée, *Ibid*, 4me Série, IV. p. 259. Domeyko, *Ibid*, 4me Série, IX. p. 445. Henwood, *Cornwall Geol. Trans.*, V. pp. 65, 109,—40, 269; *Ante*, pp. 76, 90—3,—7—121, 525. Pernollet, *Annales des Mines*, 4me Série, X. p. 421. Garby, *Cornwall Geol. Trans.*, VII. p. 87. Gregg & Lettsom, *Mineralogy*, pp. 240,—4. Salmon, *Mining Magazine*, II. 83.

* Jars, *Voyages Métallurgiques*, II. pp. 493,—5,—6. De Bournon, *Journal de Physique*, XXIV. p. 204. Schreiber, *Ibid*, p. 386. Hitchins, *Phil. Trans.*, XCI. (1801), p. 159. De Thury, *Journal des Mines*, XX. pp. 83, 90,—6. Alex. Brongniart, *Minéralogie*, II. pp. 118,—20. Vivian, *Cornwall Geol. Trans.*, I. p. 66. Carne, *Ibid*, pp. 122,—4. Berthier, *Annales des Mines*, IV. p. 472. Mohs, *Mineralogy*, II. p. 454. Phillips, *Mineralogy*, pp. 279—82. Michell, *Manual of Mineralogy*, p. 52. Levy, *Description d'une collection de Minéraux*, II. pp. 324, —8. Fox, *Report of the Cornwall Polytechnic Society*, IV. p. 92. Braun, *Annales des Mines*, 3me Série, XVIII. pp. 148,—50. Daubrée, *Ibid*, 4me Série, IV. p. 249. Henwood, *Cornwall Geol. Trans.*, V. pp. 66, 478; *Ante*, pp. 121, 526. Garby, *Cornwall Geol. Trans.*, VII. p. 87. Gregg & Letsom, *Mineralogy*, pp. 240, 302.

† De Bournon, *Journal de Physique*, XXIV. p. 212. Schreiber, *Ibid*, p. 387. Kirwan, *Mineralogy*, pp. 241,—55. De Thury, *Journal Des Mines*, XX. pp. 83, 90. Alex. Brongniart, *Minéralogie*, II. p. 209. Berthier, *Annales des Mines*, IV. p. 472. Phillips, *Mineralogy*, p. 283. Braun, *Annales des Mines*, 3me Série, XVIII. pp. 149,—51. *Ante*, pp. 121, 526.

The water * which enters the mine is fresh above, but salt below, the sea-level.†

The engines stand on a wild cliff; and in several of the drifts, extended beyond it, the workmen hear over-head—even in fine weather—the dashing of the waves and the grinding of the pebbles.

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* On the coasts of West Cornwall the mine-water is generally more or less salt. Pryce, *Mineralogia Cornubiensis*, p. 21. Hawkins, *Cornwall Geol. Trans.*, I. p. 138. Forbes, *Ibid*, II. pp. 176,—7,—9. Carne, *Ibid*, II. pp. 337,—9,—42, —3,—4. Henwood, *Ibid*, V. pp. 12, 20, 56.

At 40 fathoms below the sea in Botallack a small quantity of clear fresh water oozed out of the rock at one spot, whilst all the water around it was salt. As long as it lasted the miners collected it for drinking; but it disappeared in course of working the mine.—Forbes, *Cornwall Geol. Trans.*, II. p. 177.

† *Ante*, p. 535.

Notices of Copper Mines in Ireland.

The ores of copper occur in many parts of Ireland; but they have never been wrought to advantage except in rocks of the Silurian,*† Old Red Sandstone,‡ and Devonian, or Carboniferous,§ periods; in the counties of Wicklow,* Waterford,† Kerry,‡ and Cork.§

The copper-bearing rocks of

Wicklow,

—which have been more extensively mined than those in any other part of Ireland,—stretch from Kilmacow, across the deep Vale of Ovoca, to the Aughrim river, ‖

* Smyth, *Records of the School of Mines*, I. p. 370.

† Jukes & Du Noyer, *Explanation to accompany Sheets* 167, 168, 178, *&* 179 *of the Maps, and Sheet* 13 *of the Longitudinal Sections of the Geological Survey of Ireland*, pp. 59, 82. Jukes, *Quarterly Journal of the Geological Society of London*, XXII. pp. 323—4.

‡ Griffith, *General Map of Ireland to accompany the Report of the Railway Commissioners*. Haughton, *Journal of the Geological Society of Dublin*, VI. p. 206. Jukes, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, pp. 24—5, 37.

§ Griffith, *General Map of Ireland to accompany the Report of the Railway Commissioners*. Haughton, *Journal of the Geological Society of Dublin*, VI. p. 227. Jukes, Kinahan, Wynne, & Smyth, *Explanations to accompany Sheets* 191, 197, *&* 198 *of the Geological Survey of Ireland*, pp. 7, 20, 30. Jukes, *Notes for a comparison between the Rocks of the South West of Ireland, and those of North Devon, and Rhenish Prussia*, p. 16.

‖ "Les mines de cuivre ont été reconnues dans une étendue de 7 milles d' Ireland (environ 14 kilomètres 4-10) (3) du nord-est, au sud-ouest depuis Kilmacréa jusqu' à la montagne de Bally Coage."

Journal des Mines, No. XVI. (1795) p. 80.

"In the county of Wicklow, the metalliferous clay slate district occupies but a small space, being very narrow in breadth, and in length not more than ten miles, extending from Croghan Kinshela on the south, through the townlands of Knocknamohil and Ballymoneen, Ballymurtagh, Ballygahan, and Kilcashel, Cronebane and Tigrony, Kilmacow and Connery, towards the West Aston range on the north."—Weaver, *Geol. Trans.*, v. pp. 207—8.

"The clay slates which form the principal constituent rock of the county of

some nine or ten miles along the beds of slate, which range from north-east to south-west,* and dip towards the south-east.

Towards the north-west certain inferior members of the metalliferous series are interlaid by granular beds of felspar and hornblende. These are succeeded by mottled, pale-blue and white, fissile slates, thinly sprinkled with minute crystals of iron-pyrites. The principal portions of the formation consist, however, of homogeneous, dark-blue and variegated clay-slate, of silky lustre; often thinly cloven near the surface, but always of thick-lamellar structure at greater depths.† This sometimes alternates with thin layers of slightly-laminated, yellowish or bluish-white, argillaceous matter. In a higher part of the system a few thin,

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Wicklow are not, as a whole, remarkable for the presence of metallic minerals, either disseminated, or in veins; but a band or 'channel' of about 600 fathoms in width, coursing from the north flank of Croghan Kinshela for about 9 miles in the direction N. 40° E., exhibits at intervals a variety of metallic ores; which being in certain spots accumulated in larger quantities than elsewhere, have given rise to the long-continued mining operations in the Vale of Ovoca."

Smyth, *Records of the School of Mines*, I. p. 370.

Mahon, *The Mines of Wicklow*, p. 35.

* In 1840 the magnetic declination at Dublin was about 27° 30′ West.

Lloyd, *Phil. Trans.*, CXXXIX. p. 208. Sabine, *Ibid*, *Pl. XIV.*

† "La gangue est en général l'espèce de schiste argileux que les mineurs nomment *killas*, et qui est tendre et lamelleux, et l'argile, blanche en quelques endroits, jaune ou noire en d'autres."—*Journal des Mines*, No. XVI. p. 80.

"In the eastern bank of the Avonmore the clay slate contains some thin beds of hornstone and felspar porphyry, and to the north-west it rests upon a thick bed of greenstone, that encloses a bed of roofing slate. Beyond the greenstone, clay slate reappears in mass: all these rocks ranging north-east and south-west, and dipping 65° to the south-east. * * *

"Cronebane is flanked on the north-western and south-eastern sides, in Connery and Tigrony, by quartz rock which varies from granular to compact splintery, and abounds in contemporaneous veins of pure white quartz. The interval is occupied in part by pure clay slate, but principally by clay slate in

crumpled and fissile layers, of glossy black hue, afford, here and there, traces of carbonaceous matter. Above these—in *Connorree* and *Tigrony* at least—the clay-slate graduates into a massive siliceo-felspathic rock.

The planes of cleavage coincide with the *bedding* of the rocks; as well in their north-easterly and south-westerly direction, as in their south-easterly dip.

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almost every stage of union with quartz * * * which graduates at length into a substance which has all the characters of hornstone and even of flinty slate, and these again pass by a series of gradations into pure clay slate; a progression which is repeated likewise on the outer flanks of the quartz rock. These quartzose varieties of clay slate abound in contemporaneous veins of pure quartz, which are more or less metalliferous. * * *

The clay slate and quartzose slate contain subordinate beds of what are technically called *soft-ground.* As far as explored they vary from three to fourteen fathoms in width, and extend to an uncertain distance; but some have been traced for more than one hundred fathoms, while in depth they generally become more compact and firm. The soft ground consists of tender decomposing clay slate, varying from a light yellow or grey to a deep black colour, abounding in pyritous patches * * * and generally accompanied by a considerable body of greyish or yellowish white clay. * * * The slaty rocks (whose general range is nearly north-east and south-west, and dip south-east at an angle of 65°) are divided into great beds, by parallel seams or joints, which intersect the inclined planes of the clay slate at right angles dipping 25° towards the north-west. These seams are open fissures, which sometimes will admit one or two fingers, and at other times scarcely the blade of a knife. In their progress they pass uninterruptedly through all the beds and contemporaneous veins included in the slaty rocks, dividing them, and sometimes producing, as it were, a sensible alteration in their disposition. This tendency towards a division into horizontal beds (independent of the slaty structure) may also be observed in several parts of the district." Weaver, *Geol. Trans.*, v. pp. 214—16.

"The slates [in this neighbourhood], which from the fossils occurring near Rathdrum, are referred to the lower Silurian period, are thinly laminated, and very uniform in strike and dip, though differing so much in mineral composition as to pass through many gradations of argillaceous, talcose, felspathic, and greenstone slate. Considered under a general aspect, the hornblendic varieties occur chiefly on the lower or 'lying' side of the metalliferous portion, whilst the hanging side is occupied, on both sides of the Ovoca, by extensive roughly bedded masses of a felstone, or siliceous felspar rock, which gives rise to most of the precipitous forms between the Meeting of the Waters and the Wooden Bridge."—Smyth, *Records of the School of Mines*, i. pp. 370, 408.

Mahon, *The Mines of Wicklow*, pp. 35, 75.

The most noteworthy portion of the formation, however, is (the *Sulphur-course*) a metalliferous band, which—with few interruptions—conforms, in both bearing and inclination, to the schistose structure of the adjoining strata.*

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* "In [the] soft ground are contained one or more layers parallel to each other of copper pyrites, or mere iron pyrites, varying in thickness, and sometimes acquiring a breadth of several fathoms. * * * Thin parallel layers of ore are interstratified with the clay-slate."—WEAVER, *Geol. Trans.*, v. pp. 215—16.

"The metalliferous contents, of this remarkable series, are disposed in several groups of straight lines presenting, with a singular degree of parallelism most of the characteristics of bedded or stratified masses, such as their conformability to the beds of the slatey rock of the country, their freedom from veinstone, from 'vugs,' and from crystallized minerals, their laminated structure, and the gradual blending, in most cases, of their ores with the adjoining strata. Yet * * * they appear to cut *across the strike* of certain beds."

SMYTH, *Records of the School of Mines*, I. p. 392.

"In the Ovoca district the bed-like appearance of the sulphur-course is complete."—MAHON, *The Mines of Wicklow*, p. 73.

"Throughout its range the sulphur-course has the same underlie as the cleavage-planes of the clay-slate adjoining it."

JOHN HODGE, ESQ., Superintendent of the *Ballymurtagh* Mines, MSS.

"Les pyrites [de Fahlun] sont très variées; il en est qui sont très-riches en cuivre, avec ungrain très-fin et serré; d'autres qui sont purement martiales, encore qui contiennent du fer et du cuivre, et qui ont striée, ou plutôt d'une configuration schisteuse, comme le *schörc* avec lequel elles sont mêlées."

JARS, *Voyages Métallurgiques*, III. pp. 34,—7.

"Le terrain de transition des environs de Christiania se compose généralement de schiste argileux, quelquefois alunifère, de calcaire et de grauwacke. Des massifs de granite et de syénite s'elévent au milieu de ce terrain. * * * Loin du granite et de la syénite, les couches de transition ne renferment guère d'autre minéral métallique que la pyrite de fer; mais en général, des qu'elles s'approchent du granite, elles acquièrent des charactères particuliers. * * * C'est aussi précisément à la jonction du terrain de transition avec les roches plutoniques, que se trouvent des nombreux amas métallifères, * * *. Ces amas, de forme tout à fait irrégulière s'étendent tantôt dans la roche plutonique, tantôt, et plus fréquemment, dans le terrain de transition: dans ce dernier cas, ils s'allongent ordinairement dans le sens des couches."

DAUBRÉE, *Annales des Mines*, 4me Série, IV. pp. 232—3.

The mines of Rio Tinto, about twelve leagues west of Seville, are wrought in a formation of clay-slate traversed by dykes of porphyry, and it is near the contact of the schist and porphyry that the deposits of ore generally occur. The strike of the slates is from east to west, and the dip (except where disturbed by

Its width varies from about six * to more than seventy † feet.

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eruptive rocks) north, the angle varying but little from the vertical. The masses of mineral are usually lenticular, and have the same strike as the rocks they traverse. They are sometimes entirely imbedded in the porphyry, at others entirely in the slate; but most frequently the porphyry forms the northern wall, and the slates the southern one of the deposit.

Thomas, *Notes on the Mines of Rio Tinto* (abridged), pp. 3—4; *Mining and Smelting Magazine*, I. p. 113.

"The Rammelsberg mountain, situate near Goslar, is composed of the three lowest members of the Devonian formation of the Harz—the Wissenbach slate, the *Calceola* slate, and the *Spirifera* sandstone. Here, however, their order is reversed. the Wissenbach slate being the lowest and the *Spirifera* sandstone the uppermost member of the series. The celebrated deposit of pyrites is situated in the Wissenbach slate, which forms the base of the mountain, and which here consists of true clay slate, very generally used for roofing purposes. Above Goslar the well-defined cleavage is, as a rule, crossed at an acute angle by a not very perfectly-defined stratification. Whilst on the west slope of the Keppel Valley this divergence between the cleavage and the stratification seems to be the rule, nothing of the kind has been observed at Rammelsberg. There, on the contrary, not only does the large pyrites deposit generally coincide with the cleavage, but a zone of *Orthoceratites* and *Goniatites* found under the pyrites is also parallel to the cleavage. It is therefore probable that in the Rammelsberg, as far as it consists of Wissenbach slate, the cleavage and stratification coincide. * * * The body of ore strikes between hours 4 and 5 (E. 15°—30° N.) and its dip varies, but is mostly at an angle of 45° S.S.E. Its length on the line of its direction also varies, and decreases in depth, The width of the undivided mass is reckoned from 35 to 40 fathoms; but at a depth of 62 fathoms, it separates into two *branches*, one of which wedges out at a depth of 82 fathoms in the *hanging-wall*, whilst the principal *branch*, on the *foot-wall*, goes to a greater depth."—Von Cotta, *Berg-und Hütten*, Zeit, No. 45, 1864. *Mining and Smelting Magazine*, VII. (1865), pp. 151—4.

Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edinburgh, and Dublin Phil. Mag.*, 3rd Series, XXV. p. 344; *Ante*, pp. 187, 207.

* *Table XVIII.*

† "There occurred [in Connary], some years ago, a 'bunch' of ore 72 feet in width."—Smyth, *Records of the School of Mines*, I. p. 383.

"Unquestionably the most remarkable lode [in Ballymurtagh] now, is the 'Great North Lode.' On the surface of the hill * * * appears a large bed of gossan, composed of brown hæmatite iron, which reaches the enormous width of 100 feet. This gossan, which is an excellent iron ore 52 per cent. produce, worth 15*s*. or 16*s*. per ton, has been worked as a quarry. * * *

"At the eighteen-fathom level the 'Pond lode' is found to be seventy feet wide." Mahon, *The Mines of Wicklow*, pp. 51—2.

Earthy brown iron-ore, sparingly interfoliated with slate, is its chief ingredient to a depth—of seven fathoms at *Connorree** on the N.E.;—of a few feet in one bed but of sixteen fathoms in another at *Ballymurtagh*† on the S.W.;—and still deeper at *Cronebane*‡ midway between *Connorree* and *Ballymurtagh.*

In, and immediately beneath, the *(gossan)* earthy brown iron-ore, towards the N.E., small quantities of galena are, now and then, associated with minute proportions of silver, and sometimes mixed with either blende, the sulphuret of antimony, earthy black copper-ore, vitreous copper, copper-pyrites, or iron-pyrites,§

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* *Table XVIII.*

† "The Sulphur-course afforded large quantities of yellow copper-ore close to the surface in *Ballymurtagh* and *Ballygahan;* but the *back* of our Great North Sulphur-course, for about sixteen fathoms in depth, is composed of the peroxide of iron."—John Hodge, Esq., MSS.

‡ "In some parts of its course this bed did not produce copper ore till nearly at the depth of forty fathoms from the surface, the upper part consisting principally of a brown indurated oxide of iron."—Weaver, *Geol. Trans.*, v. p. 216.

§ "In sinking the shafts at Crone-Bawn the first mineral met with is an iron-stone. Beneath this they arrive at a lead ore, which seems mix'd with the clay, yet yields a large quantity of lead and some silver. Under this lies a rich rocky silver-ore, which sparkles brightly, and yields seventy five ounces of pure silver out of a ton of ore, beside a great quantity of fine lead. Having pierced some fathoms thro' this, they arrive at the copper ore, which is very rich."

Henry, *Phil. Trans.*, xlvii. (1751—2), p. 501.

"Connery contains a bed of ore about four feet thick, consisting of a fine grained intermixture of galena, grey ore of antimony, and blende, with pyrites of copper, iron, and arsenic. * * * A similar compound occurs in the * * * upper [part of] Cronebane."—Weaver, *Geol. Trans.*, v. p. 215.

A newly discovered lode, or bed of sulphur ore, in the Ballymurtagh district, contained a massive mineral, of leaden colour with a tinge of brown. Its specific gravity was 4·4955; but it exhibited numerous intermixed particles of yellow iron pyrites.

On its analysis the following results were obtained:—

Bisulphuret of Iron, ...	$Fe\ S_2$, ...	24·92
Sulphuret of Iron, ...	$Fe\ S$, ...	9·33
Sulphuret of Lead, ...	$Pb\ S$, ...	19·13
Sulphuret of Zinc, ...	$Zn\ S$, ...	46·62
		100·

and, as in other places under similar conditions,* occasionally with more than one of them. At greater depths, the brown ore is, in some measure, replaced by argillaceous matter, and yet deeper the ores of lead, zinc, and antimony gradually disappear.† Still down-

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Neglecting the iron pyrites, which is obviously a mechanical intermixture, the residual constituents are very accurately expressed by the formulæ

$$Fe\,S + Pb\,S + 6\,Zn\,S.$$

Apjohn, *Journal of the Geol. Soc. of Dublin*, v. p. 134 (Abstract).

"At Berggieshübel in Saxony, deposits of this order, containing magnetic iron, copper ores, zinc blende, galena, with garnet, quartz, &c., follow very regularly the strike and dip of the environing clay-slates, the latter varying from 15° to 90° to the north-east. Near the surface were found in place of the above, red and brown ores of iron, with barytes."

Smyth, *Records of the School of Mines*, i. p. 392.

Analyses of ores from *Connorree* and [of blue-stone from] the *Pary's* mine.—

	Connorree.	*Pary's.*
Lead	13·	16·
Silver	—	a trace.
Zinc	17·	34·3
Copper	6·1	1·5
Iron	21·	11·9
Sulphur	37·2	29·3
Alumina	3·	—
Silex	—	7·
Water and loss	2·7	—
	100·	100·

MSS. of the late Percival Norton Johnson, Esq., F.R.S., F.G.S.

* "Dans la contrée de Christiania * * * on y a trouvé les substances minérales suivantes: fer oxydulé, fer pyriteux, galène argentifère, blende, pyrite de cuivre, cobalt gris, fer arsenical, bismuth sulfuré, molybdène sulfuré, cobalt oxydé, &c."—Daubrée, *Annales des Mines*, 4me Série, iv. p. 233.

"The ore [of Rio Tinto] is essentially iron pyrites, but is accompanied by a small per-centage of copper pyrites and some silex, say one or two per cent.; galena and blende are also found in small quantities."

Thomas, *Notes on the Mines of Rio Tinto*, p. 4.

"At Rammelsberg the mass of the deposit consists of sulphur pyrites, with but a small admixture of copper pyrites. In some localities, however, copper pyrites, galena, and blende are frequent; sometimes even predominating."

Von Cotta, *Berg-und Hütten*, Zeit. No. 45, 1864. *Mining and Smelting Magazine*, vii. (1865), p. 157.

† *Ante*, p. 545, Note §.

ward the earthy black copper-ore is mostly determined towards the *(foot-wall)* N.W., whilst the iron-pyrites generally approaches the *(hanging-wall)* S.E. side.* At the deepest point hitherto attained in this direction, however, iron-pyrites and slaty clay prevail for the entire width; but, notwithstanding small masses and short narrow veins of copper-pyrites occur at intervals, —all trace of separate bedding has disappeared.*

Towards the S.W. earthy brown iron-ore forms a crust, of inconsiderable thickness, on the surface of the *Sulphur-course;* † but at a distance of one hundred

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* *Table XVIII.*

On the Sulphur-course the peroxide of iron disappears within a few feet of the surface; but on the Great North Sulphur-course—a parallel bed, about one hundred and twenty-five fathoms distant, towards the N.W.—it has been largely worked to a depth of sixteen fathoms. The oxide iron overlies yellow copper-ore mixed with iron pyrites in the former, and iron pyrites sprinkled and veined with yellow copper ore in the latter; but earthy black copper ore has been of rare occurrence in Ballymurtagh and Ballygahan.

John Hodge, Esq., MSS. (Abridged.)

"The back of the north lode is characterized by a bed of brown hæmatite, of which an average specimen gave—

Peroxide of iron	74·37
Clay and Silica	11·
Water	14·12
Volatile matter and loss	0·51
	100· "

Haughton, *Journal of the Geol. Soc. of Dublin*, v. p. 281.

† At Ballymurtagh "the surface has been marked by huge projecting masses of 'gossan' or hydrous peroxide of iron. * * * The great metalliferous deposit * * * consists, at a small depth from the surface, of 12 feet in width of granular iron pyrites, of a pale colour, altogether free from gangue or vein-stone. * * *

"About 120 fathoms to the north of the principal vein, large masses of 'gossan' composed chiefly of fragments of slatey rock cemented by brown oxide of iron, had long ago induced the commencement of mining operations. It is, however, only within the last three years, that more efficient trials have been

and twenty-five fathoms on the N.W. the *Great North Sulphur-course*—a parallel band of great width yet unrecognized in other parts of the district—is rich in the same mineral, to a depth of sixteen fathoms.* Earthy black ore—of which *gossan* is an ordinary matrix, as well in many another copper region † as in the N.E. of this—is an uncommon ingredient in the S.W.; whilst of vitreous copper, galena, grey antimony, and blende, which had been sometimes obtained in *Connorree* and *East Cronebane*, no trace has been yet discovered at either *Ballymurtagh* or *Ballygahan*. The portions which immediately succeed the brown iron-ore, in both metalliferous beds, consist mostly of copper-pyrites and iron-pyrites; but—although the former is, perhaps, rather more plentiful in the *Sulphur-course* than in the *North-course*,‡—no considerable part of either is of uniform composition.

Notwithstanding the *Great North-course* and vari-

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crowned with the success of discovering a parallel course of iron pyrites of remarkable size and solidity, * * * the breadth of the new lode averaging 24 feet." Smyth, *Records of the School of Mines*, I. p. 372—3.

"The surface of the 'Sulphur course' is marked with great masses of 'gossan.' Near the surface the sulphur is twelve feet wide, and this width increases with the depth, in the limit of about eighty fathoms from the surface.

"About 120 fathoms north of the 'Sulphur course' a bed of 'gossan' of 100 feet in width is succeeded, at between 20 and 30 fathoms in depth, by the ordinary sulphur ore." Mahon, *The Mines of Wicklow*, p. 50.

* *Ante*, p. 547, Note †.

† Pryce, *Mineralogia Cornubiensis*, p. 88. Henwood, *Cornwall Geol. Trans.*, v. p. 205. Whitney, *Metallic Wealth of the United States*, p. 322. Ansted, *Quarterly Journal of the Geological Society*, XII. p. 149; XIII. pp. 241,—8,—9.

‡ "This formation yields annually about 30,000 tons of iron-pyrites containing about— 0·340 its weight of sulphur, and
0·005 ,, copper."
John Hodge, Esq. (1867), MSS.

ous distant portions of the *Sulphur-course* crop out at different elevations;* iron and copper pyrites, both at *Connorree* on the N.E. and at *Ballymurtagh* on the S.W., become predominant ores on nearly the same horizon.†

But, beside the ores of iron, copper, lead, zinc, and antimony, traces of virgin silver and of native copper have been observed occasionally; and microscopic particles of gold are thinly sprinkled through many—if not through all—parts of both the *Sulphur courses.*

At *Connorree* small proportions of gold have been obtained as well from silvery lead-ore near the surface, as from the pyrites at greater depths.‡

In *East Cronebane* shallow parts of the *Sulphur-course* have afforded threads of auriferous silver.§

At *Ballymurtagh* gold is associated with the earthy brown iron-ore which abounds in the upper portions of both the *Sulphur-courses;* but the only reliable

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* The *Sulphur-course* crops out at *Connorree* .... about 790 feet above the sea;
" " *Ballymurtagh* " 430 " .
The *Great North Sulphur-course*.. " " " 500 " .
SMYTH, *Plans and Sections of the Ovoca Mines.*

† At *Connorree* the 54-fm. *level* on the *Sulphur-course* .... is about 450 feet above the sea;
" *Ballymurtagh* the outcrop of the *Sulphur course* .... " 430 " ;
" " the 16-fm. *level* on the *Great North Sulphur-course* .. " 430 " .
Ibid.

‡ *Journal des Mines*, No. XVI. (1795) p. 82. Smyth, *Records of the School of Mines*, I. p. 389. Mahon, *The Mines of Wicklow*, p. 63. *Postea.*

§ " Towards the middle of the last century, a brown indurated oxide of iron, which formed the upper part of a metalliferous bed in the higher grounds of Cronebane, was found to contain minutely disseminated native silver, sometimes in extremely slight filaments, but generally in particles quite imperceptible to

analysis shows that it averages less than (0·000010 the weight) one-third of an ounce to the ton of vein-stone. The more deeply-seated pyritous parts of both formations are also auriferous, but in a still smaller degree.*

Earthy matter is much more abundant near the sides † than in the middle of the *Sulphur-course*. At

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the eye. The silver was extracted by fusion with lead, and subsequent cupellation. It contained about thirty grains of gold in the ounce equivalent to (0·0625 its weight) $6\frac{1}{4}$ per cent. and hence, the auriferous silver commonly sold for half a guinea an ounce. Articles made from both the metals so extracted are in the possession of a family in the county."

Weaver, *Geol. Trans.*, v. p. 213.

Smyth, *Records of the School of Mines*, i. pp. 380,—9. Mahon, *The Mines of Wicklow*, pp. 57, 63.

* In 1854 a considerable quantity of *gossan*—[carefully selected from shallow parts of the Great North Sulphur-course in Ballymurtagh] —was submitted to operation in two machines then newly invented for washing gold. The results reported to have been obtained were—

		dwts.	grs.	
in the first machine	at the rate of	17	12	(0·000027 its weight) of gold per ton of ore;
,, second ,, ...	,,	7	12	(0·000011 ,,) ,, ,, ;
,, ,, ,, another experiment,	,,	more than an ounce		.... ,, ,, .

The Directors of the [Wicklow Copper Mines] Company having little confidence in such conflicting results from the very same ore, placed other samples of it in the hands of Professor Apjohn, M.D., F.R.S., M.R.I.A., of Trinity College, Dublin, whose analysis showed much smaller proportions of gold than the lowest of those reported by the mechanists.

Other experiments were afterwards made at the mine under advice from the late Mr. Evan Hopkins, F.G.S., but the results obtained were even smaller than those of Professor Apjohn. * * *

Gold is sprinkled through the iron-pyrites in both the Sulphur-courses; but the proportion is even smaller than in the gossan. * * *

John Hodge, Esq., MSS. (Abridged.)

† "The pyrites does not appear to occur in a regular lode or vein with definite walls, but to be diffused through the slate which forms the country in beds, which are stratified conformably with the slate itself; it does not occur pure, but intimately mixed with the slate."

Haughton, *Journal of the Geol. Soc. of Dublin*, v. p. 280.

"The great metalliferous formation * * * [is] not bounded by distinct walls, but ceases by gradual interlamination with the clay-slate. * * *

"A large proportion of pyrites is left unworked, in consequence of its being too much mingled with other substances to be available by the processes at present employed."—Smyth, *Records of the School of Mines*, i. pp. 372,—91.

intervals, however, slices *(horses*)* of clay-slate, occasionally many fathoms in length and height, but often merely a few inches,† though sometimes several feet, in thickness,—as at *Bunna* in Kumaon,‡ *Morro Velho* § in Brazil, and at the *Buckingham*,‖ as well as at the *Garnett* and *Moseley*,¶ mines in Virginia—interlie the ore,** but such subordinate layers often enclose crystalline granules of the neighbouring minerals.

Several well-marked lines of structure divide the metalliferous deposit into slightly undulating beds (*combs* ††), somewhat differing—but rarely exceeding a foot—in thickness. In each of these—as in the formation generally—the argillaceous ingredients are less plentiful near the middle than towards the sides. To certain depths much of the ore—like the rock which alternates with it—is so fissile that—even in course of extraction—it cleaves into plates no thicker

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 211,—29.

† "At Ballymurtagh * * * extensive workings carried on by the 'old men' on the copper lode were divided * * * by laminæ of slates * * * only a few inches thick from excavations in progress on the 'sulphur-course,' where the latter was very wide."—Smyth, *Records of the School of Mines*, I. p. 375, *Fig.* 12.—Mahon, *The Mines of Wicklow*, p. 92. *Table XVIII.*

‡ *Ante*, p. 20.

§ *Ibid*, p. 191.

‖ *Ibid*, p. 378.

¶ *Ibid*, p. 381.

** *Table XVIII.*

†† Pryce, *Mineralogia Cornubiensis*, p. 95. Werner, *New Theory of the formation of Veins*, p. 83. Weaver, *Geol. Trans.*, v. p. 215. Fox, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 89. De la Beche, *Report of the Geology of Cornwall*, &c., p. 339. Henwood, *Cornwall Geol. Trans.*, v. p. 179, 201; *Ante*, pp. 85, 433,—68. Daubrée, *Annales des Mines*, 4me Série, IV. p. 238. Smyth, *Records of the School of Mines*, I. p. 383. Mahon, *The Mines of Wicklow*, p. 61.

than roofing-slates,* and exfoliates on the slighest exposure; but still deeper this character gradually disappears.† The confronting sides of many longitudinal *partings* — although often uneven — present scored, but glossy, faces of *(flucan)* unctuous clay. Of the striæ short portions may be, here and there, straight and parallel; but for the most part they are crooked and divergent. On opposite sides of the same beds, indeed, they dip, not only at divers angles,

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* "The sulphur-ore of Ovoca is easily split into slices as large and thin as the best Cornish roofing-slates; their planes of cleavage coinciding, in both dip and direction, with those of the adjoining *(Country)* slate-rocks."—Henwood, *Proceedings of the Royal Geological Society of Cornwall*, 9th Oct., 1840; *West Briton*, 16th Oct., 1840; *Mining Journal*, 24th Oct., 1840.

"It may even be remarked of the masses or 'cobs' of ore brought to the surface, that when struck with a hammer they have no tendency to break with the usual fracture * * * but split in the direction of the lamination."
Smyth, *Records of the School of Mines*, i. p. 372.

"In the Ovoca district the * * * ore does not break with the fracture of ordinary copper or iron-pyrites, but splits up like any other tough schist; it has quite a differentappearance when looked at along the plane of the bedding, or across that plane, and the richest qualities pass gradually, and by imperceptible changes, *first*, into a pyrites containing more schisty matter; *second*, into what is called by the miners a *sulphury killas*, containing perhaps 50 per cent. of pyrites; and *lastly*, into schist, impregnated with less and less sulphur, until finally that mineral disappears."—Mahon, *The Mines of Wicklow*, p. 73.

"At Rammelsberg the deposit of sulphur pyrites * * * seems in reality to consist of several more or less lenticular agglomerations separated one from another by thin strata of slate. * * * The general parallelism of the masses of ore with the cleavage and stratification [of the rock] is in favour of their contemporaneous origin, as well as their inner texture, for in the compactness of the pyrites there is very generally to be observed a distinct layer-like arrangement, running parallel with the cleavage and stratification. * * *

"The pyrites deposit of the Rammelsberg is by no means a solitary instance. There, are, on the contrary similar deposits at Agordo, Schmöllnitz, and Fahlun."
Von Cotta *(Berg-und Hütten*, Zeit. No. 45, 1864), *Mining and Smelting Magazine*, vii. pp. 155—6.

† Weaver, *Geol. Trans*, v. p. 214. *Ante*, p. 541.

but sometimes towards different points of the compass.*

Notwithstanding small local flexures,—the *Sulphur-course*,—the layers of slate which interlie it,—the subordinate beds into which it is divided,—and the slices of schistose ore,—all—conforming to the cleavage of the adjoining *(Country)* rocks—incline towards the S.E.

Layers of pyrites, often less than an inch but sometimes a foot in thickness, accompany the *Sulphur-course* within short distances, for great part of its range if not throughout the district; † but whether any of them represent, in *Tigrony*, *Cronebane*, and *Connorree*—N.E. of the *cross-course*,—the *North Sulphur-course*

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 172,—82, *Tables XVIII. XCV.*; vii. p. 180, *Table I.*; *Ante*, pp. 259,—64, 433,—69.

† "Beds of iron-pyrites * * * have appeared in the firm clay slate and quartzy clay slate, in the deep levels of *Cronebane* and *Tigrony*. And thin layers and slight threads of copper pyrites and iron pyrites are very frequent."

Weaver, *Geol. Trans.*, p. 216.

"At present five lodes or beds are worked on the Ballymurtagh mine, parallel to each other, and conformable to the bedding of the hornblende and quartz rock of the district."

Haughton, *Journal of the Geological Society of Dublin*, v. p. 280.

"On the north of the great metalliferous deposit [in Ballymurtagh] to the distance of 100 fathoms, and on the south for 20 fathoms, parallel veins of cupriferous pyrites have been met with, sometimes very numerously; but only in the case of those which lie within a distance of 50 feet to the south, profitable in extraction. * * * [Between the great metalliferous deposit and] * * * a parallel course of iron pyrites of remarkable size and solidity * * * about 120 fathoms to the north * * * two intermediate lodes have been discovered, one of which offers a good width of iron pyrites with $1\frac{1}{2}$ per cent. of copper, and occasional ribs of higher produce."

Smyth, *Records of the School of Mines*, i. p. 372—4. (Abstract.)

"In Ballygahan * * * the coppery rib of the pyrites deposit * * * is succeeded at 9 fathoms farther south by the 'main lode,' (which above the adit level has also a 'north branch'), at 2 fathoms again by 'Barry's lode,' and at 2 fathoms further by 'Tuke's lode.'"—*Ibid*, p. 376.

"On the eastern side of the Ovoca, at the mines of Tigroney and Lower

which has been, hitherto, wrought only at *Ballymurtagh*—on the S.W.—is yet unknown.*

A few, comparatively narrow, ranges of vein-stone—resembling beds in some, but *lodes* in other, respects, yet possessing certain characters common to both—maintain the same direction as the laminæ of (*Country*) slate, but differ from them, and sometimes indeed from one another, in dip; † whilst certain—hardly parallel veins, of similar composition, are oblique to them as well in bearing ‡ as in underlie. Those which comply

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Cronebane, the beds of decomposing and variously coloured slates, together with the 'sulphur course' and the 'copper lodes' on the south, are evidently the continuation of the deposits of Ballygahan."

Smyth, *Records of the School of Mines*, i. p. 378.

"At Connary * * * several irregular copper lodes occur on the south, all confined to the silicio-felspathic rock."—*Ibid*, p. 384.

Journal des Mines, No. xvi. (1795) p. 81. Mahon, *The Mines of Wicklow*, pp. 49, 55,—8, 62.

* "It is by no means uncommon for *lodes* to split directly at the point of their intersection by a *cross-course* or *flucan*, on one side of which the *lode* appears in two *branches*, whilst, on the opposite, but one *branch* occurs."

Henwood, *Cornwall Geol. Trans.*, v. p. 176.

† "In Cronebane several contemporaneous veins of quartz * * * mostly range and dip with the clay slate, ramifying in their extremities through the rock; or sometimes coalescing again, they form a considerable body, * * *. There are several small ones of this description in Upper Cronebane, and in the lower mine there are six in the vicinity of the Copse and Boundary shafts, and two in that of the Farmer's shaft."—Weaver, *Geol. Trans.*, v. p. 216.

Table XVIII.

‡ "The most remarkable of the secondary veins is, first, the 'Magpie' running N.W. & S.E., 4 to 8 feet wide, and producing copper pyrites and also native copper in quartz; secondly the 'yellow ore vein,' coursing from E.S.E. to W.N.W., varying from 18 to 20 inches in width, and affording copper pyrites in a gangue of quartz and killas; the third is the 'copse north vein,' which runs N. & S., is 8 to 24 inches wide, and contains the same minerals as the last; fourth, the 'copse south vein,' with a width of 18 to 36 inches, and similar ores. The two last are supposed to form a junction with the principal lode on the S.W., where it was found accompanied by a parallel vein which appeared to be

with the first conditions can, of course, meet on their lines of inclination only;* whilst such as scarcely coincide in either their direction or their dip,—bearing generally a few degrees N. of E.—S. of W. and inclining at somewhat different angles towards the S.,—not only interfere with each other in both their strike and underlie,† but—slightly converging in their range W.‡—approach, and at length become incorporated with, the *Sulphur-course*.§

The subordinate beds and *side-lodes*—marked with a family likeness to the *Sulphur-course* — enclose conformable layers of slate, beside small quantities of—occasionally granular—quartz, spotted sometimes with chlorite,|| and—less frequently—with calcareous

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on the line of their prolongation."

Journal des Mines, No. xvi. (1795), p. 81 (Translation). Smyth, *Records of the School of Mines*, i. p. 389. Mahon, *The Mines of Wicklow*, p. 72.

* Haughton *Journal of the Geological Society of Dublin*, v. p. 281. Smyth, *Records of the School of Mines*, i. p. 372. *Postea*, p. 557.

† Smyth, *Records of the School of Mines*, i. p. 373. *Postea*, p. 556.

‡ "Lodes more frequently split as they go eastward than westward."
Henwood, *Cornwall Geol. Trans.*, v. p. 176.

§ Smyth, *Records of the School of Mines*, i. p. 379—80. *Postea*, p. 556.

|| "Contemporaneous veins of quartz, accompanied sometimes by chlorite, occur [in various parts of Cronebane]."—Weaver, *Geol. Trans.*, v. p. 216.

At Ballymurtagh "quartz spar * * * composed of sugary quartz, presenting the vughy appearance which is considered by working miners so valuable an indication * * * is of common occurrence."
Haughton, *Journal of the Geol. Soc. of Dublin*, v. pp. 280—2.

"The copper lode [in Ballymurtagh], although varying much in thickness has none of the characteristic appearances of a vein; its ore is the * * * ordinary copper pyrites, and is of very low per-centage owing to the admixture of iron and of portions of quartz and talcose or sometimes chloritic slate, never occurring in a fragmentary state, but interlaminated sometimes so delicately as to appear in fine films, and contorted like the adjacent rock."
Smyth, *Records of the School of Mines*, i. p. 372.

matter.* Throughout their range they contain considerable quantities of iron-pyrites; which, to certain depths, are mixed with earthy black copper-ore, and with vitreous copper towards the north-east; † but often give place to yellow copper-ore in the central and south-west parts of the district. Native copper ‡ occurs in most of them; but in minute proportions, and very rarely. Where such layers and veins unite with one another or merge in the *Sulphur-course*, whether on their lines of bearing §

"To the south of the Sulphur-course [in Cronebane, and] answering, it is supposed to the South or copper-lode in Ballymurtagh and Ballygahan, are several quartz veins rich in copper-pyrites, accompanied sometimes with beautiful specimens of the carbonates, and not unfrequently by chlorite."

MAHON, *The Mines of Wicklow*, p. 58.

* "I have found also in the lower levels of the copper lode [at Ballymurtagh], carbonate of lime, containing a considerable quantity of magnesia. This occurs in a green greasy slate."

HAUGHTON, *Journal of the Geol*, *Soc. of Dublin*, v. p. 580.

† *Ante*, p. 547; *Table XVIII.*

‡ In the north sulphur-lode at Ballymurtagh "a quantity of native copper, 28 lbs. in weight was recently found [1853]."

HAUGHTON, *Journal of the Geol. Soc. of Dublin*, v. p. 281.

At Connary "the frequent lining of joints and cracks by a film of crystalline native copper proves that *anogenic* chemical action, or that which proceeds downwards from the surface, has been rife even to a great depth."—SMYTH, *Records of the School of Mines*, I. p. 384.

Table XVIII.

§ "In Cronebane several contemporaneous veins of quartz bearing rich copper-pyrites, accompanied sometimes even by earthy azure copper ore, * * * and whose average produce is ten to twelve per cent. of copper, also occur, and more particularly in the quartzose slate. * * * The union of several such form a considerable body, even twelve feet wide of vein, and four or five feet wide of solid ore; but they seldom continue productive for more than thirty fathoms in length.—WEAVER, *Geol. Trans.*, v. p. 216.

In Cronebane "the first 'copper lode' is sometimes interrupted by a cross-deposit of limited length which appears to stop it for a time on its line of strike. * * * The ore in general only produces from 4 to 8 and rarely 10 per cent. * * * [but] such 'T's,' as they are called by the miner, * * * yield for a

or dip,* they commonly yield copper-pyrites on both sides of the contact. Such bodies of ore—often several feet in thickness and sometimes many fathoms in length and height—mostly yield a larger per-centage of metal than the smaller *bunches* which are imbedded in, and more or less mixed with, sulphur-ore.

The *Sulphur-course* suffers several interruptions.

S.W. of *East Cronebane* the indications, whether of sulphur or of copper ore, are so slight and unpromising, that a line of shallow *(Costean-)* pits, and a single drift (the *Cronebane level)*, have been thought sufficient examination.† The former extends about three hundred, the latter—with its flexures and ramifications—more than five hundred fathoms; but neither has been wrought for half a century. After an interval of one

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length of 8 or 10 fathoms, and heighth of 20 or 30, * * * copper ore of somewhat higher per-centage.

SMYTH, *Records of the School of Mines*, I. pp. 379—80. (Abridged.)

At Ballymurtagh "a cross-fissure, the sides of which were encrusted with crystallized copper pyrites and quartz, was found between the 33 and 66-fathom levels; with a course nearly at right-angles to that of the main lode, it came up to, but did not pass its north wall. * * * Its width was irregular; yet was sufficient to enable it to be worked 'on tribute' for some 20 fathoms in length."

Ibid, p. 373.

* "In Ballymurtagh "the pyrites lode joins the copper lode at about the 56 fathom level, below which there is only one lode, which is worked to a depth of 160 fathoms, the lower part being particularly rich in copper."

HAUGHTON, *Journal of the Geol. Soc. of Dublin*, V. p. 281.

"The iron pyrites has not been found in available quantity at a greater depth than 100 fathoms; it appears to grow thinner at about 80 fathoms from the surface, and then to unite with the copper 'lodes,' as they are termed, on the south, forming together at the 56-fathom level a 'bunch' of copper ore, 24 feet in width. This vein was in one spot by the addition of numerous bands of greater or less thickness, and on both sides, increased to nearly 60 feet.

SMYTH, *Records of the School of Mines*, I. p. 372.

† Weaver, *Geol. Trans*, V. *Pl.* 12, *Plan and Sections of the Copper Mines in Cronebane and Tigrony*. Smyth, *Plan and Sections of the Ovoca Mines*.

hundred and thirty fathoms the surface-works re-appear;* and some thirty fathoms N.W.—on the (R.G.A.) right—of the *Cronebane level*,† underground-operations have extended, with great, though varying, success, through *Cronebane* and *Tigrony*, to the vale.

Between the N.E. boundary of *Tigrony* and the river the *Sulphur-course* is intersected by three cross-*(flucans)* veins of slaty clay; of which

the first bears ‡	about	10° W. of N.—E. of S.;	dips E. 50°—55°;	& measures some	6 ins. in width:
„ second ‡	„	34° W. of N.—E. of S.;	dips E.—N.E. 85°;	„	3 „ :
„ third ‡§	„	N.—S.;	dips E. 65°—70°;	„	12 feet „ .

The *Sulphur-course* is *heaved*;—

by the first.... 13 fms. (R.—S.A.) towards the right-hand and to the side of the smaller angle;

„ second.. 2 „ (L.—G.A.) „ left-hand and to the side of the larger angle;

and it abuts on the E. side of the (great) third *flucan*; but whether it is represented on the W. by a broad,

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* "Towards the N.E., beyond the 'Mosey' shafts, the strike of the beds appears to have suffered some disturbance; and their continuity is somewhat uncertain, since through a space of 800 feet in length, no workings have been carried on, with the exception of some shallow shafts, long since filled up."
Smyth, *Records of the School of Mines*, I. p. 380.

† "In West Cronebane the *Sulphur-course* continued very productive as far towards the north-east as the Government Plan shows a continuance of shallow pits. At that spot, however, it abuts on a joint *(Head)* similar to many found in this district. Within a range of about five hundred fathoms many trials to recover it have been made in the same direction, but all have been unsuccessful, until East Cronebane is reached; and even here the formation has not been nearly so productive as it was in West Cronebane."—John Hodge, Esq., MSS.

‡ George Oates, Esq., Superintendent of *Tigrony*, *Working-plan of the Mine*.

§ Haughton, *Journal of the Geological Society of Dublin*, V. p. 279. Smyth, *Records of the School of Mines*, I. pp. 378,—94. Mahon, *The Mines of Wicklow*, p. 76.

though comparatively unproductive, bed about seventy-two fathoms (L.—G.A.) towards the left-hand and the greater angle,*†–by some other band hitherto unrecognised on the S.,—or by the *Sulphur-course* wrought —some 287‡—324* fathoms, or even more,§ distant—at *Ballygahan*|| in the same direction (L.—G.A.), is yet undetermined.

In *Ballygahan* three neighbouring joints, alike faced with clay, bear 12°—15° W. of N.—E. of S., and—slightly inclining, at intervals, to one side or other—are, on the whole, nearly perpendicular. They all *heave* the *Sulphur-course;* the first and second from the N.E., about three fathoms each;—the third, rather more than four fathoms at one *level* but to greater distances both above and below;¶ for, owing to flexures, of both the *Sulphur-course* and the joints, the

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* *Ante*, p. 558, Notes ‡§.

† "In Tigrony the great bed of sulphur-ore is rich to its contact with the cross-course or flucan that runs through the valley. With a view to recovering it, beyond this towards the S.W., long and tedious examinations have been made on both sides. All those on the *right-hand* have failed to find even a trace of ore; at a distance of about seventy fathoms to the *left*, however, a metalliferous bed nearly ten fathoms wide has been discovered, but hitherto it has not realized expectation."—John Hodge, Esq., MSS.

‡ Smyth, *Plan and Section of the Ovoca Mines.*

§ Smyth, *Records of the School of Mines*, I. pp. 378,—94; *Pl. II.* Mahon, *The Mines of Wicklow*, p. 76.

|| *Postea*, p. 560.

¶ "About 15 fathoms east of the 'Blue shaft' [in Ballygahan] the 'sulphur-lode' is heaved a few feet to the north; and 30 fathoms farther, two more dislocations occur, the fragment of the lode being in each case about 2 fathoms long, and separated from the other part about 3 fathoms. Towards the river, it seems probable that the more considerable disruption takes place, which heaves or throws the beds in a horizontal direction to the northward, to Tigroney mine." * * * .

same *heaves* respectively are seldom of identical distances at different depths; all, however, are towards the *left-hand*, and to the side of the greater angle (L. G.A.).

Between the joints and *(flucans) cross-veins* which traverse the vale, the *Sulphur-course* is much less productive* than in *Cronebane* and *Tigrony* towards the N.E., and in *Ballygahan* and *Ballymurtagh* on the S.W.

Although the produce of various mines has been differently stated,† Official Returns ‡ show that from 1840 to 1866

"Westward of the engine shaft, 112 feet, the pyrites course is met with by a 'slide' pointing a few degrees west of north, and is heaved to the south a distance of 55 feet, whilst the 'copper lodes' appear to be unmoved by any dislocation, and are thus much nearer to the great deposit in the western, than in the eastern part of the mine."

Smyth, *Records of the School of Mines*, I. pp. 376—7.

"In Ballygahan the *flucan-head* heaves the *Sulphur-course*—

at the 18 fathom level	...... 11·4	fathoms,	to the left;	
30 „	...... 13·6	„	„	;
50 „	...... 4·0	„	„	;
60 „	...... 8·8	„	„	.

"From the surface to the 60 fathom level, the joints are, on the whole, nearly vertical."— Henry Robinson, Esq., of *Ballygahan*, MSS transcripts of the Working-plans.

"In Ballygahan three *heads* or joints,—which bear about 15° W. of N.—E. of S. and dip sometimes W., though perhaps more frequently E., but are on the whole nearly perpendicular,—severally heave the Sulphur-course short distances towards the left-hand."—John Hodge, Esq., MSS.

* "Near the river the lodes are so entirely broken up by these *heaves* as to become quite valueless."—Mahon, *The Mines of Wicklow*. p. 55.

"In Tigrony the metalliferous bed west of the *flucan* affords only a few small ribs of sulphur ore."—John Hodge, Esq.. MSS.

† Smyth, *Records of the School of Mines*, I. pp. 374,—82,—91. Haughton, *Journal of the Geological Society of Dublin*, v. p. 284. Mahon, *The Mines of Wicklow*, pp. 53,—4, 98.

‡ Returns from the Custom House (of which those for 1840—52 are quoted by

105,432 tons *(Avoirdupois)* of copper-ore, and
1,960,119 „ „ „ iron-pyrites *(sulphur-ore)*,—
beside very considerable quantities of hematite and earthy brown iron-ore,—have been exported from the district.

Mr. Smyth, *Records of the School of Mines*, I. p. 391; and by Mr. Mahon, *The Mines of Wicklow*, p. 98) show the shipments at Dublin, Wicklow, and Arklow to have been—

Years.	Copper-ore. Tons (*Av.*)	Iron pyrites (Sulphur ore). Tons (*Av.*)	Totals. Tons (*Av.*)	Years.	Copper ore. Tons (*Av.*)	Iron pyrites (Sulphur ore). Tons (*Av.*)	Total. Tons (*Av.*)
1840..	12,001	42,185	54,186	1854..	1,063	81,215	82,278
1..	5,397	81,257	86,654	5..	185	38,672	38,857
2..	11,741	42,480	54,221	6..	415	65,215	65,630
3..	9,279	41,145	50,424	7..	135	89,685	89,820
4..	10,670	36,709	47,379	8..	47	104,095	104,142
5..	10,391	40,969	51,360	9..	27	112,966	112,993
6..	8,723	37,863	46,586	1860..	89	109,418	109,507
7..	5,045	42,533	47,578	1..	92	78,227	78,319
8..	4,102	43,301	47,403	2..	71	75,944	76,015
9..	4,139	47,908	52,047	3..	974	66,771	67,745
1850..	4,545	77,746	82,291	4..	3,943	73,089	77,032
1..	2,167	107,560	109,727	5..	4,225	98,080	102,305
2..	2,942	102,887	105,829	6..	1,873	114,153	116,026
3..	1,151	108,046	109,197				

Totals :—

Copper-ore................	105,432 *(Avoir.)* tons;		
Iron-pyrites *(Sulphur-ore)* ..	1,960,119	„	„ .
Total....	2,065,551	„	„ .

For nearly one hundred and twenty years * the mine-water of Ovoca has deposited large precipitates of copper; † but of the quantities obtained from 1840 to 1866, full particulars are inaccessible.

In 1856 the cost of extraction, carriage and shipment averaged about eleven shillings per ton of sulphur-ore.‡

The wages of the miners

in 1752		were four shillings a week ;§
but between 1840 and 1862 they ranged from eleven shillings and sixpence to thirteen shillings	and averaged about ..	twelve „ „ .

* Henry, *Phil. Trans.*, XLVII. (1752) p. 500.

† The quantity of copper-precipitate *(poudre cuivreuse)* exported was

in 1788	....	11·50 tons,
9	....	37·00 „ ,
1790	....	59·75 „ ,

which yielded on an average 0·328 its weight of metal.

Journal des Mines, No. XVI. (1795) p. 85.

" During Mr. Weaver's management [? 1787—1811] the mineral waters flowing from Cronebane and Tigrony yielded 442·59 tons of precipitated copper (mixed with the oxide of iron) which sold on an average for £27 : 8 : 9 per ton, being in aggregate value £12,126 : 18 : 1½."

Weaver, *Geol. Trans.*, v. p. 218. Smyth, *Records of the School of Mines*, I. p. 387. Mahon, *The Mines of Wicklow*, p. 78.

‡ " The cost to the different mining proprietors of raising and putting on board the sulphur from their respective mines, is, as nearly as possible, as follows:—

	Connorree.			*Cronebane.*			*Ballygahan.*			*Ballymurtagh.*		
	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
Breaking in the mine, drawing to the surface, and separating from waste	0	4	0	0	5	0	0	3	6	0	5	0
Carriage { to Wicklow in horse-carts..	0	4	0	0	4	0						
Carriage { „ Arklow by railway	......			......			0	1	6	0	2	0
Dues, agencies, & wear of machinery	0	2	0	0	2	0	0	2	6	0	2	6
Shipping-charges, commission on sales, &c.	0	1	6	0	1	6	0	1	6	0	1	6
℔ ton	0	11	6	0	12	6	0	9	0	0	11	0

Mahon, *The Mines of Wicklow*, p. 96.

§ "There are five hundred men employed in Crone Bawn * * * their pay is eight pence a day."—Henry, *Phil. Trans.*, XLVII. p. 501.

Connorree—situate at the N.E. extremity, and in the most elevated part, of the district, is wrought in clay-slate of which the portion beneath the great metalliferous horizon is generally homogeneous, thick lamellar, and of dark-blue colour;* the lower beds are interlaid by a band of felspar irregularly mixed with hornblende;† whilst some of the upper members alternate with thin fissile (? carbonaceous) layers of blackish hue.‡ The somewhat softer and more cloven slates, which succeed the pyritous part of the series, are of paler tint than those below it; and—especially on approaching the siliceo-felspathic rocks which overlie them,§—they are frequently mottled with white.‖ The planes of cleavage have, in at least one part of *Connorree*, a different direction from the average they maintain throughout their range;¶ thus—

in the S.W. of *Connorree* they bear about 20° E. of N.—W. of S.;
,, district generally ,, ,, N.E.—SW.

Their dip is invariably towards the E. or S.E.**

The several metalliferous beds preserve the same

* *Ante*, p. 541.

† Weaver, *Geol. Trans*, v. p. 170. Smyth, *Records of the School of Mines*, I. p. 370. *Ante*, p. 541.

‡ Weaver, *Geol. Trans.*, v. p. 215. Smyth, *Records of the School of Mines*, I. pp. 380,—3. Mahon, *The Mines of Wicklow*, p. 61. *Ante*, p. 542.

§ Weaver, *Geol. Trans.*, v. p. 171. Smyth, *Records of the School of Mines*, I. pp. 370,—80,—1. Mahon, *The Mines of Wicklow*, pp. 36, 75. *Ante*, p. 542.

‖ *Table XVIII*, column 6.

¶ Weaver, *Geol. Trans.*, v. p. 217, *Pl.* 12. Geological Survey of Ireland, *Plan and Section of the Ovoca Mines*. *Ante*, p. 542.

** Smyth, *Records of the School of Mines*, I. p. 383; *Fig.* 17. Mahon, *The Mines of Wicklow*, p. 61. *Ante*, p. 542.

strike,* and—with but a single exception†—the same inclinations,* as the cleavage-planes of the slates which form their opposite *(walls)* sides.

The deposits most largely wrought are

Wall's lode........	from 3 to 4 feet in width,	
the *South branch*...	„ 3 „ 4 „ „ ,	
the *Sulphur-course*..	„ 4 „ 41‡ „ „ ;	

beside several of smaller size, considered unworthy of pursuit.

Wall's lode, at a depth of ten fathoms, consists of slaty-clay, granular quartz, earthy brown iron-ore, and friable iron-pyrites, often slightly mixed with, and at intervals enclosing, small masses of, pulverulent black copper-ore. The chief ingredients—the quartz and the pyrites especially—affect distinct beds; and sometimes they encompass and isolate thin conformable *(horses)* layers of slate, identical with the slate *(Country)* on either side, as well in their composition as in the dip of their cleavage; but—although inclining no more than 50°,§—they never touch it.

The *South-branch*—presenting the same anomaly as the *Main lode* at *Bearhaven*,‖ inasmuch as it is more highly inclined than the cleavage-planes of the

* Smyth, *Records of the School of Mines*, I. p. 383,—4. Mahon, *The Mines of Wicklow*, p. 60. *Ante*, pp. 543,—53, *Table XVIII.*

† Smyth, *Records of the School of Mines*, I. p. 384. *Ante*, p. 554, *Table XVIII.*, *Postea*, p. 565.

‡ Smyth, *Records of the School of Mines*, I. p. 383. *Ante*, p. 544.

§ *Table XVIII.*, columns 3, 6.

‖ *Postea*, *Table XX.*, columns 3, 6.

slates in its opposite *(walls)* sides,*—is in great measure composed of friable iron-pyrites unequally mixed with argillaceous matter; and of granular quartz, either flecked with native copper,† or thinly sprinkled and slightly veined with vitreous copper and with copper-pyrites; earthy black copper frequently invests the grey and yellow ores, but sometimes it is also diffused through the earthy matrix. The principal constituents form, here and there, ill-defined bands parallel to the underlie of the vein.

The *Sulphur-course*, to about seven fathoms from the surface, affords earthy brown iron-ore in abundance, slaty-clay more sparingly, iron-pyrites in smaller quantities, and—towards the N.W. *wall* especially—earthy black copper-ore in even more minute proportions. At greater depths, however, the opposite sides of the deposit assume different characters. *The N.W., or lower, portion*, contains much friable quartz, quartzose slate, and slaty-clay, more or less mingled with granular iron-pyrites; and earthy black copper-ore—often sprinkled through the pyritic part—is sometimes the chief component.‡ In the shallower *levels* the pulverulent ore comprehends,—for a width of from four

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* *Table XVIII.* columns 3, 6.

† *Journal des Mines*, No. xvi. (1795) p. 81. Smyth, *Records of the School of Mines*, i. pp. 384,—9.

‡ "In 1833 we discovered at the depth of 25 fathoms a bunch of black copper ore, which was worked for many fathoms to a width of more than 40 feet."

MSS. (14th February, 1840) of the late Nicholas Kempston, Esq., sometime Superintendent of *Connorree*.

Smyth, *Records of the School of Mines*, i. p. 383. Mahon, *The Mines of Wicklow*, p. 60. *Ante*, p. 544.

to forty feet,—masses and veins of copper-glance;* but downward—where narrower—it includes also like aggregations of copper-pyrites.† *The S.E., or upper, part* of the *Sulphur-course* in *Kilmacow* on the N.E., consists, at about ten fathoms deep, of iron-pyrites and argillaceous matter; showing frequent traces of earthy black copper-ore, and enclosing, at intervals, *bunches* of galena which has afforded auriferous silver.‡ Near the middle of the mine, the iron-pyrites and slaty-clay between the eighteen and the twenty-five fathom *levels,* enclose small separate masses of argentiferous lead-ore, beside large isolated bodies in which the sulphurets of zinc, lead, copper, and iron—with the sulphuret of antimony at times—are either intimately mixed or chemically combined.§

From the twenty-five to the forty-five fathom *level* a broad band of iron-pyrites and slaty-clay || remained

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* Smyth, *Records of the School of Mines,* I. pp. 383—94. *Ante,* p. 548.

† Smyth, *Records of the School of Mines,* I. pp. 384,—94. *Ante,* p. 549.

"The *lodes,* which yield copper ores in slate * * * are frequently spotted with earthy black copper ore near the surface; lower down, however, this is succeeded by vitreous copper; and, at length, by copper pyrites."
Henwood, *Cornwall Geol. Trans.,* v. pp. 228—9.

‡ "A Connery, tout près de la grande route, dans la partie du filon qui se dirige vers le nord-est, ce filon s'élargit beaucoup près de la surface de le terre, et contient une galène à grain d'acier mêlèe de *killas,* très-difficile à fondre, qui rend environ 25 p.$\frac{0}{0}$ de plomb, contenant 1 once et $\frac{1}{2}$ (0·000905) d'argent par quintal. Le chapeau du filon a offert, en plussieurs endroits, une substance semblable à de l'ocre, qui contenait jusqu'à $\frac{1}{2}$ p. $\frac{0}{0}$ (0·005) d'argent, et un peu d'or."—*Journal des Mines,* No. XVI. (1795) p. 82.

Smyth, *Records of the School of Mines,* I. p. 389. MSS. of the late Nicholas Kempston, Esq.

§ Weaver, *Geol. Trans.,* v. 215. Apjohn, *Journal of the Geol. Soc. of Dublin,* v. p. 135. Smyth, *Records of the School of Mincs,* I. p. 394. Mahon, *The Mines of Wicklow,* p. 58. *Ante,* pp. 545,—6.

|| "As the *Sulphur-smalls* of *Connorree* are largely mixed with clay, and may

unwrought for several years after the underlying body of rich copper-ore* had been removed. This volume of sulphur-ore is mixed throughout with larger or smaller quantities of several copper-ores; but—as in many other localities†—earthy black ore prevails in the shallower, and copper-pyrites is even more plentiful in the deeper, parts of it. Below the forty-five-fathom *level* the beds on opposite sides lose, in some measure, their distinctive characters; the N.W., or lower, layers consisting of iron-pyrites largely charged with argillaceous matter, whilst the S.E., or upper, portions afford isolated *bunches* of the same sulphur-ore, as well as small bodies of copper-pyrites and still smaller masses of vitreous copper encrusted with earthy black ore, in a matrix of slaty-slay. Within a short distance, however, lenticular aggregations of iron pyrites, and thin beds of copper-pyrites ‡ invested with black copper-ore, are imbedded in granular quartz interlaid with slate.§ The continuation, at a depth of 84 fathoms, consists of slaty-clay, sprinkled, and sometimes veined, with both sulphur-ore and copper-pyrites.|| ¶

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therefore be readily made into balls for burning; they are preferred by the manufacturers to the less earthy *smalls* of *Cronebane* and *Ballymurtagh*."

JOHN HODGE, ESQ., MSS.

* *Ante*. p. 565.

† *Ibid*, p. 566.

‡ Smyth, *Plan and Sections of the Ovoca Mines; Records of the School of Mines*, I. p. 383. *Ante*, p. 556.

§ Smyth, *Records of the School of Mines*, I. p. 383, *Fig*. 17. Mahon, *The Mines of Wicklow*, p. 61.

|| Smyth, *Records of the School of Mines*, I. p. 394. *Ante*, p. 547; *Table XVIII.*

¶ Markham Browne, Esq., Resident Director, and W. G. Roberts, Esq., Manager, of *Connorree*, MSS.

In shallow parts of the mine the poorer sulphur-ores afforded on an average (0·000122 their weight) four *(Troy)* ounces of silver per ton; * but at greater depths the *(sulphur-smalls)* softer varieties—which are more mixed with clay than the ores of *Cronebane, Tigrony, Ballygahan* and *Ballymurtagh*,† — have yielded from (0·000184—0·000582) six to about nineteen ounces.*‡ Gold occurs, not only in alloy with silver, but in separate grains; * and, in one assay at least, it was obtained in the proportion of (0·000015 the weight §) half an ounce to the ton of ore.*‡

Numberless masses *(horses)* of slate, frequently less than a foot, though sometimes several feet, in thickness, and often a few feet only, but occasionally many fathoms, in length and depth, notwithstanding they are bounded—as well above and below as at the sides and ends—by metalliferous ingredients alone, maintain, as a general rule, the selfsame mineral composition as the *(country)* rocks, which, at the same levels respectively, form the sides *(walls)* of the *Sulphur-course;* ‖ yet, now and then, they contain small quantities of ore.

The bodies of iron-pyrites and copper-ore, which envelop these *horses* of slate, exhibit the same remark-

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* *Ante*, p. 567, Note ¶. † *Ante*, p. 566, Note ‖

‡ "For some years past the extraordinary and staple comodity of Connorree has consisted of decomposed argentiferous iron pyrites, containing from six to twelve ounces of silver and about half an ounce of gold per ton, and of from one to two per cent. of copper."—Mahon, *The Mines of Wicklow*, p. 63.

Ante, p. 549.

§ *Table XVIII.*

‖ *Ante*, pp. 20, 191, 378,—81, 550,—64; *Tables XVIII., XX.*

able schistose structure * that prevails, to considerable depths, amongst similar ones, in other parts of the *Sulphur-course.*†

The cleavage-planes, as well of the pyrites and of the slates within it, as of the *(Country)* rocks above and beneath,‡—maintain the same dip and direction as the *Sulphur-course* § itself and the *horses* ‖ it includes.

Two series of joints intersect the *Sulphur-course*; ¶ one,—inclining more highly than it is inclined, but nearly parallel to it in direction—bears 30°—40° E. of N.—W. of S.; the other ranges 22°—27° W. of N.—E. of S., but—unlike the slightly diverging joints in *Cronebane* ** and *Ballygahan* ††—it occasions no displacement.

Throughout the district copper is still precipitated from mine-water, but of late the stream from *Connorree* has been the most productive; for some time, indeed, it acted so strongly on the iron pit-work, that beechen *plungers* ‡‡ were used, and—as in some parts of

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* Henwood *Proceedings of the Royal Geol. Soc. of Cornwall (West Briton)*, 16th Oct., 1840; *Mining Journal*, 24th Oct., 1840). Smyth, *Records of the School of Mines*, I. p. 372. Mahon, *The Mines of Wicklow*, p. 73. Von Cotta *(Berg-und Hütten*, Zeit. No. 45, 1864); *Mining & Smelting Magazine*, VII. pp. 155—6.

† *Ante*, pp. 551,—2.

‡ *Ibid*, p. 564; *Table XVIII.*

§ *Ibid*, pp. 563,—4.

‖ *Ibid*, p. 564.

¶ *Table XVIII.*

** *Ante*, p. 558.

†† *Ibid*, pp. 559—60.

‡‡ "We have now at work *a wooden plunger-pole* made of this Country beech,

Cornwall—the pumps were lined with thin slips of pine.*

From the end of September, 1838, to the beginning of April, 1839, about 3,559,358 cubic feet, or 99,312 tons, of water were drawn to the surface.†

This passed from the pump-head, and from one to another of several successively lower tanks, through

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and we have a second ready for use; both have been soaked in the mine-water, which is a capital substitute for Kyan's patent. The pumps are lined with wood which will save the inside from the action of the water, and the flanges will be protected as much as possible by well tarred hoods of canvass."

MSS. of the late Nicholas Kempston, Esq.

In the last century it was suggested to the Admiralty, by the late Captain Hercules Michell, that timber intended for ship-building should be immersed in the water of the great Gwennap adit."

Henwood, *Cornwall Geol. Trans*., v. p. 458*, Note 2.

"About the year 1801 [the late] Captain Joel Lean * * * first introduced, at Crenver and Oatfield, (what is now so generally used and with such great advantage,) the plunger-pole, instead of the common box and piston."

Lean, *Historical Statement of the Improvements made in the Duty of Steam Engines in Cornwall*, pp. 8, 9.

Smyth, *Treatise on Coal and Coal-Mining*, p. 181.

The late Benjamin Sampson, Esq., of Tullimaar near Truro, and the late Mr. Francis Michell, Engineer, of Redruth, informed the writer,—that, "in 1796, they had seen the *plunger-pole* applied at *Ale and Cakes* in Gwennap, by Mr. Murdock, who then directed the affairs of Messrs. Boulton & Watt in Cornwall; and that they had reason for believing it had been previously worked at another, mine in the neighbourhood."

Henwood, *West Briton* (xxxi. No. 1606), 23rd April, 1841.

* "When the water is saline or acidulous * * * the working-barrel, ordinarily of cast iron duly bored, is sometimes made of brass or gun metal (as, indeed, it very often was in earlier days); or, as in some of the copper mines in Cornwall, the whole of the pump-work may be lined with staves of wood, carefully fitted like an internal cask, to prevent the rapid destruction which otherwise ensues."—Smyth, *Treatise on Coal and Coal Mining*, p. 180.

† The steam-engine had a stroke of seven feet in the shaft, and—ranging from four to eleven—averaged, during the period under consideration, about seven strokes per minute. The calculated, is assumed to bear to the actual, discharge, the same proportion (1· to ·924) which they bore to one another during repeated experiments at *Wheal Towan* in Cornwall. Henwood, *Transactions of the Institution of Civil Engineers*, ii. p. 58.

narrow inclined channels (*launders*). The floors of the former were nearly horizontal, but those of the latter were slightly inclined; the water, therefore, flowed less rapidly through the one than through the other.

The capacity of the tanks was about 3447 feet;
" *launders* " 900 " .

Both were thickly spread with scraps of wrought iron and shreds of tin-plate, which were frequently turned and swept; in order—by the removal of the precipitated copper—to present a surface of iron as clean as circumstances permitted, to the impregnated mine-water.

Accounts kept at the mine show, that during this period

		tons (*Avoir.*)
the tanks and *launders* were supplied with about	62·0000	of wrought-iron and tin plate;
of which .... nearly	20·0000	were consumed;
and this precipitated	19,9375	of copper,

which realized in the market £894 : 10 . 9.

The precipitate was, therefore, 0·9969 the weight of the iron it had replaced; and
0·0002 " of the mine-water from which it had been obtained.

During 1861—2 the consumption of........	124	tons of *scrap-iron*, &c.,
collected	60	" precipitate,
which yielded on an average	0·44	its weight of copper.
The precipitate was therefore	0·48	the weight of the iron,
and the copper "	0·21	" " .

The precipitation was always more rapid in running than in still water; and in warm than in cold weather.

The water took with it, from the precipitation tanks and *launders*, a considerable proportion of iron-ochre, most of which subsided in pits prepared for its reception; the rest passed off, in suspension, to the river.

At *Cronebane* * it appears that in 1862

	30 tons of	wrought-iron	
afforded	12 „	precipitate,	
which contained 35 per cent. of copper.			

In this case, therefore, the precipitate was	0·400	the weight of the iron dissolved		
„ copper „	0·140	„	„	, &
„ „ „	0·350	„	of the precipitate.	

* "In order to carry off the water from [Crone Bawn] there are levels carried on a great way under-ground, from the lower part of the hill. Out of these levels issue large streams of water, most strongly impregnated with copper.

"An accidental discovery, which happen'd not long ago, is like to make these streams more beneficial than all the rest of the mines. Some of the workmen, having left an iron shovel in the stream, found it some weeks after incrusted with copper. This gave the hint of laying bars of iron in these streams, which is done in the following manner:

"Oblong pits are dug, ten feet long, four wide, and eight deep: the bottom laid with smooth flags; the sides built up with stone and lime, with wooden rude beams across the pits to lay the iron bars on. Chains of these pits are continued along the stream as far as the directors please; for the water never abates of its quality. * * * Soon after the iron bars are laid in these pits, they contract a copper rust, which, by degrees, intirely eats away the iron. The copper, which is in the water, being thus continually attracted and fixed by the iron, subsides to the bottom of the pit. To hasten this dissolution, the iron bars are sometimes taken up, and the rust rubb'd off them into the pit. In the space of twelve months the whole bar is commonly dissolved, if the iron be soft; for steel or hard iron will not do here. The stream is then turned off the pits; and the men with shovels throw up the copper, which lies at the bottom like reddish mud. This mud [when] dry becomes a reddish dust * * *. It is then smelted into copper. * * *.

"One ton of iron in bars produces a ton and 19 hundred and an half weight of this copper mud or dust. Each ton of this mud produces, when smelted, 16 hundred weight of the purest copper, which sells at ten pounds *per* ton more than the copper, which is made of the ore. There are about 500 tons of iron now laid in these pits. The water, that runs from these mines, enters the river Arklow at New Bridge; and is of so corrosive a nature that no fish can live in this large river from hence to the sea."

Henry, *Phil. Trans.*, xlvii. (1751—2) pp. 500—3.

According to Dr. Henry's statement, therefore,

the precipitate obtained was	1·975	the weight of the iron used;		
„ fine copper „ „	1·580	„	„	;
„ „ „ „	0·800	„	precipitate.	

"L'eau de la mine est toujours plus chargée de la parties salines et métalliques en hiver qu'en été; ce qui vient, suivant M. *Mills* de ce que l'air sec qui circule

The water of *Ballymurtagh* * gave, from 1852 to

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pendant l'été dans les mines, y favorise la cristallisation du sulfate de cuivre, tandis que pendant l'hiver, qui est toujours pluvieux en Ireland, les eaux qui s'infiltrent dans les filons redissolvent les dépôts salins, et s'enrichissent par-là considérablement.

"On augmente aujourd'hui la concentration de l'eau retirée de la mine, au moyen du minérai pyriteux pauvre. C'est même presque pour ce seul usage qu'on prend la peine de l'extraire ; car, quoique ce minérai soir le plus abondant, cependant, comme on a vu, on n'en exploite qu'une petite quantité. Après l'avoir brisé en morceaux d'une grosseur convenable, on le met dans les fours qui contiennent de 50 à 150 tonneaux de minérai. On n'a besoin, pour commencer à y mettre le feu, que de quelques broussailles et d'un peu de charbon ; après quoi, le soufre contenu dans le minérai suffit pour entretenir la combustion. Ce soufre, volatilisé par la chaleur, est reçu dans des récipiens adaptés à ces fours. * * * Après que le minérai a ainsi subi le grillage, on le porte dans des fosses remplies d'eau vitriolique, où on le laisse plongé quelque temps, après quoi on le passe au bocard; on lave ensuite celui qui en vaut la peine."

Journal des Mines, No. XVI. (1795) pp. 83—5.

"The process [of roasting] commonly lasted six weeks, * * * and when it was well managed, a nucleus of rich yellow or grey sulphuret of copper, surrounded by brownish red oxide of iron, might be found in each piece of the burnt ore. In this state, the ore being steeped in water, a solution of sulphate of copper was obtained, and the copper precipitated by iron; the kernels of the sulphuret * * * were separated from the slimy oxide by washing."

Weaver, *Geol. Trans.*, v. p. 219.

Percy, *Metallurgy*, I. pp. 439—47.

In July, 1791 it was found that the water

as it issued from the mine	contained 0·00383	its weight of sulphuric salts	and 0·00004	its weight of copper;
when it had passed over the calcined ore	„ 0·00962	„	„	„ 0·00084	„
after it had rested for some time on calcined ore in the tanks	„ 0·27006	„	„	.	

The precipitate contained on an average 0·328 its weight of copper.

Journal des Mines, No. XVI. (1795) pp. 84—5.

Smyth, *Records of the School of Mines*, I. pp. 385—9. Mahon, *The Mines of Wicklow*, pp. 41—2. *Ante*, p. 562.

"The mine-water of *Cronebane* contains now (1862) a smaller proportion of copper than it contained formerly."

Captain John Reed, Manager of *Cronebane*, MSS.

* "Il y a déjà environ cinquante ans que l'opération de cémentation est en usage dans les mines de Ballymurtagh, dont l'exploitation, ou plutôt la reprise dans les derniers temps, a précé de celle des mines de Cronebane. * * *

1861, the undermentioned quantities and qualities of precipitate.*

Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in	Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in
1852 ...	6·0	0·4500	1853 ... continued.	6·0	0·4200
	4·5	0·4900		4·0	0·4275
1853 ...	3·0	0·3975		7·0	0·5500

Suivant Berkenhout, l'eau de Ballymurtagh dépose par l'évaporation 7 gros et ½ de sédiment, et celle de Cronebane, 4 gros 16 grains.

Journal des Mines, No. XVI. (1795) pp. 83,—5.

"The water issuing from the pyrites workings [in Ballymurtagh] is strongly impregnated with copper, and on being passed over plates of iron yields a precipitate containing from 10 to 30 per cent. of copper."

HAUGHTON, *Journal of the Geological Society of Dublin*, V. p. 284.

Smyth, *Records of the School of Mines*, I. pp. 386. Mahon, *The Mines of Wicklow*, pp. 41—5.

* John Hodge, Esq., MSS.

A comparison of the before-mentioned results with those obtained in other districts, can scarcely be without interest.

The enormous body of ore discovered near Amlwch, in Anglesea, on the 2nd of March, 1868,[ab]—of which the produce lowered, for some years, the price of copper throughout Europe and threatened the poorer mines of this kingdom with ruin,[c]—has been wrought in the *Parys* and *Mona* mines, without intermission until now (1868).

The blackish and greyish-blue clay-slate, immediately beneath, become more and more quartzose as they approach it: certain portions, transfused with siliceous matter, displaying a flinty character;[cdef] whilst other parts are made up of slate and quartz in distinct and separate laminæ; several large, and exclusively siliceous, beds of schistose structure[cf] enclose, here and there, bodies of massive quartz; and broad bands of greyish hornstone[cf] occur at intervals. The slate directly overlying the ore is generally brownish; but—exhibiting various colours within short distances—it passes gradually into the normal blue.

a Pennant, *Tours in Wales*, Edit. 1810, iii. p. 60.
b *Journal des Mines*, No. xvi. (1795) p. 69.
c Hawkins, *Cornwall Geol. Trans.*, iii. pp. 285,—9,—91.
d Ramsay, *Memoirs of the Geological Survey*, iii. p. 195.
e Henslow, *Cambridge Phil. Trans.*, i. p. 384.
f Frère-Jean, *Annales des Mines*, xiii. pp. 229—35.

Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in	Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in
1853 ... continued.	6·5	0·5775	1854 ... continued.	2·5	0·4625
1854 ...	5·5	0·3600		4·0	0·6537
	8·0	0·3775	1855 ...	0·5	0·1500

Many beds are sprinkled and veined with siliceous substances; [a] but these rarely accompany the thick conformable layers of metalliferous quartz which have been largely worked in northern parts of the mines.

South of the great metalliferous deposit—where little or nothing of much value has yet been found—the planes of cleavage—maintaining a tolerable regularity—bear nearly E. and W.[b] In other parts of the district, however, their directions are less uniform: for the average of their many large flexures in the *Mona* mine, towards the N.E., is 12°—30° S. of E.—N. of W.,—near the boundary of the mines they range about E. and W.,—and in the *Parys* works, on the N.W., some 15°—25° N. of E.—S. of W. Moreover the wide floor of copper-bearing quartz, worked to a greater or less extent in various parts of both mines—as the *Carreg-y-doll* "*lode*"—is subject to like flexures; and the smaller metalliferous beds—severally known,—as the *Clay-shaft* "*lode*" and the *Charlotte* "*lode*" in the E.,—as the *North Discovery* "*lode*" towards the W.,—and as the *Black-Rock* "*lode*" throughout—also conform to the undulations in their respective neighbourhoods. The relations between the great metalliferous deposit and the rocks adjoining it are not now very readily discerned; its general direction, however, is some 12°—15° N. of E.—S. of W.; [b] and its dip—like the dip of other productive beds of quartz and the cleavage-planes of the neighbouring slate—ranges from 50° to 84° and averages, perhaps, 65° towards the N. The formation is intersected by joints of two series; which—differing both from the copper-yielding beds and from the *cross-veins (flucans)* in direction—bear [b] 25°-35° W. of N.—E. of S. and 30°-40° N. of E.—S. of W. respectively. Two *cross- (flucan) veins* traverse the district; namely,—the eastern or *Carreg-y-doll cross-course* which ranges some 5°—15° E. of N.—W. of S., and the great, or *western, cross-course* which takes a nearly meridional bearing. Both the *cross-veins heave* the smaller productive beds *("lodes")* they encounter, towards the *(L., G.A.,) left-hand* and to the side of the greater angle; [c]—the *Carreg-y-doll cross-course* displacing the *Charlotte* "*lode*" but slightly,—the *Carreg-y-doll* "*lode*" about twelve—, and the *Black Rock* "*lode*" nearly eight, fathoms;

a Frère-Jean, *Annales des Mines*, xiii. pp. 229—35.

b In 1840 the Magnetic declination at Dublin was about 27° 30′ West.—Lloyd, *Phil. Trans.*, cxxxix. p. 208.

Sabine, *Ibid*, *Pl. XIV*. *Ante*, p. 541, Note *.

c Henwood, *Cornwall Geol. Trans.*, v. p. 287.

Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in	Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in
1855 ... continued.	6·0	0·4625	1856 ... continued.	3·5	0·4750
	1·5	0·4750	1857 ...	5·0	0·2937
1856 ...	4·0	0·4175		3·0	0·4875

whilst the *western cross-course* dislocates the *Carreg-y-doll* " *lode* " as much as thirty fathoms. Both cut through the great metalliferous deposit also; but the extent of any *heaves* they may have occasioned, is concealed by the rubbish which now covers the sides of the openings wherein it was formerly wrought.

The *North Discovery* (bed) " *lode* " varies from about two to eight feet, the *Carreg-y-doll* " *lode* " from one fathom to nearly ten fathoms, in width; both enclose conformable *(horses)* masses of slate; and consist in great measure of quartz, quartzose slate, chlorite, and disintegrated felspar, mixed, however,—with earthy brown iron-ore as well as with smaller quantities of native copper, earthy black copper-ore, the sulphate of lead, and other rare minerals, near the surface,—with yellow copper-ore and specular-iron at greater depths,—and with larger or smaller proportions of iron pyrites throughout.

The great metalliferous deposit appears [a] not only to have occupied the whole space between the *Clay-shaft* " *lode* " and the *Black Rock* " *lode* " for a considerable distance, but also to have extended some way N. of one and S. of the other.

It has been wrought open to the day

for about 90 fms. on the line of its strike, and more than } 140 fms. in extreme width in the } *Hill-side open-cast;* and
,, 210 ,, ,, ,, 90 ,, ,, ,, *Great open-cast:* [ab]
to a depth of 18 fathoms,[ab] and for an area of 5·331 acres, in the former;[abc] and
,, 23 ,, ,, ,, 12·131 ,, ,, latter: ,,

and to greater depths, for short distances, in both. The *open-casts* [ac] are separated by a body of vein-stone, varying from ten to fifty fathoms in thickness, whence small quantities of copper-ore are still extracted.

The principal earthy ingredients—as in the smaller productive beds on the N.—are quartz and quartzose slate, through which chlorite is thinly, and rather unequally, sprinkled; towards the E., however, and especially near the *(foot-*

a Working-plans of the *Parys* and *Mona* mines.

b Pennant, *Tours in Wales* (Edit. 1810) iii. pp. 65, 436,—8; *Journal des Mines,* No. xvi. (1795), p. 73. Hawkins, *Cornwall Geol. Trans.*, iii. pp. 284,—8. Frère-Jean, *Annales des Mines,* xiii. p. 229. *Amlwch and the celebrated Mona and Parys Copper-mines* (Beaumaris, 1848), p. 5.

c The *open-cast* of *Wheal Music,* wrought on copper-veins, in slate, near Redruth, measures about an acre;
,, *Carclaze,* ,, on tin-veins, in granite, near St. Austell, measures about five acres.

Thomas, *Cornwall Geol. Trans.*, v. pp. 98, 120.

Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in	Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in
1858 ...	2·5	0·2525	1859 ...	5·5	0·3675
	4·0	0·3800		4·0	0·3800
	4·0	0·3812		2·5	0·6125

wall) lower side, buff-coloured felspar is also abundant. Thin fissile layers of blackish-blue slaty matter interlie the other constituents, dividing them into ill-defined beds, parallel to the adjoining rocks. Shallow parts of the *Mona* mine have afforded much *(gossan)* earthy brown iron-ore, containing nests of earthy black copper-ore, and small cavities incrusted with the carbonates of copper and the sulphate of lead. Beds, laminæ, interlacing veins, isolated bodies, single crystals, and disseminated grains of iron-pyrites even yet abound in the quartzose and slaty portions of the mass. Galena occurs in some, and blende in other, parts of the formation; and occasionally the intractable association of both these, with iron and copper pyrites *(Blue-stone* [a] *)* has been plentiful. Native copper, earthy black copper-ore, vitreous copper, and purple ore have been frequently obtained; [b] the principal produce, however, has always been copper pyrites. Great quantities were, of course, scattered through the earthy matrix; but during three months of the year 1787, one party of workmen extracted "two thousand nine hundred and thirty-one tons of good copper-ore and only ninety-two tons (0·031 its weight) of waste." [c] On one occasion forty-four thousand tons of ore lay ready for the furnace. [b] In both the *open-works* several large *(horses)* masses of quartzose slate, interlaid by laminæ, and intersected by thin veins, of iron pyrites, have—by the removal of the copper-ore which surrounded them—been left standing as isolated crags.

Between the two enormously rich *(bunches)* portions of the great metalliferous deposit, wrought in the *Hill-side open-cast* and the *Great open-cast* respectively, a body of comparatively unproductive—yet slightly orey—quartzose vein-stone intervenes; whilst—like many of the largest *courses* of tin and copper-ore in Cornwall, [d]—each of them is intersected by a *cross-vein*. Both the *cross-veins* partake, to some extent, the character of the *ore-ground* they traverse; for the most part, however, they consist of slate identical, in both composition and structure, with the *(country)* rocks adjoining: that is to say,

a Ante, p. 546.

b Pennant, *Tours in Wales,* iii. p. 61.

c Price, *Ibid,* p. 438.

d Carne, *Cornwall Geol. Trans.,* ii. p. 99. Fox, *Reports of the Royal Cornwall Polytechnic Society,* iv. (1836) p. 88. Henwood, *Cornwall Geol. Trans.,* v. pp. 32, 233; *Tables VIII. XXIV. XLII.,—V., LIII., LX.,—I.,—II.,—V.,—VIII., LXXXI.,—VII.,—IX.*

Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in	Years.	Precipitate. Quantities of (tons)	Precipitate. Proportion of copper in
1860 ...	4·0	0·4425	1860 ... continued.	3·5	0·6125
	4·0	0·4875	1861 ...	3·5	0·3062
	5·0	0·5550		3·75	0·3850

they—as well as several of the Cornish *cross-veins*—are mere slices of the strata, containing little or no ore. [a]

The richest part of the *North Discovery* (bed) " *lode* " is intersected, at about right-angles to its course, by two nearly vertical joints; but the poorer portions are traversed by several such seams,[b] all which dip towards the W.

The body *(courses)* of ore,—both in the great deposit and in the *North Discovery* "*lode*"—have also a westerly *(shoot)* dip endlong, but at a lower angle.

To a depth of eighteen fathoms in one part, and of twenty-three in another, the great metalliferous mass was *quarried* for its entire width. At these respective levels, however, " not only had the body of ore diminished, but it was of lower quality, [whilst] the expenses of raising it had increased inversely in the same proportion.[c] " *Quarrying* was, therefore, discontinued; and mining operations were commenced on the richest of the tributary or subordinate parts—the *Black Rock* (bed) " *lode;* " which—by aid of a steam-engine —set up at the bottom of the *Great open-cast*—is still *mined* some sixty-five fathoms below the surface.

The *North Discovery* " *lode* " is worked to a depth of about one hundred and twelve fathoms.

The richer ore was *dressed* in the ordinary manner;[d] the poorer was broken to about the size of eggs, and burnt. " For which purpose it was placed between two parallel walls of vast length; some kilns were twenty, others forty, or fifty yards in length; some ten, others twenty feet wide, and above four feet in height. The space within was not only filled, but the ore was piled many feet higher, * * * the whole was then covered with flat stones, closely luted with clay * * * in order to prevent the fumes from escaping. The ore was set on fire by a very small quantity of coal, and it then burnt *per se.* The sulphureous particles passed off into long flues built of brick, where they subsided in form of the finest brimstone. Some of the [kilns] contained

a Henwood, *Cornwall Geol. Trans.*, v. pp. 261,—3, *Table LXIX.*

b *Ibid*, p. 232.

c Hawkins, *Ibid*, iii. p. 287.

d Pryce, *Mineralogia Cornubiensis*, pp. 233—43. Henwood, *Cornwall Geol. Trans.*, iv. pp. 159—65. Henderson, *Proceedings of the Institution of Civil Engineers*, xvii. pp. 16—20.

From 1852 to 1856	therefore, 72·50 tons		of precipitate were obtained, and the proportion of copper—ranging from 0·1500 to 0·6537—averaged 0·4634 its weight;
but from 1857 to 1861	„ 54·25 „		of precipitate were obtained, and the proportion of copper—ranging from 0·2525 to 0·6125—averaged 0·4207 only;

four hundred tons of ore, others two thousand; the first required four months to be completely burnt; the last near ten."[a]

The results of these operations—which have been discontinued here since 1862—were identical with those obtained at Agordo in the Venetian Alps; [b] that is to say:—

"1*st stage*.—When a lump of ore in this stage is broken across, it is seen to consist of a central mass of unchanged ore, enclosed, as it were, in a rind or shell of a reddish-brown substance like sesquioxide of iron; and between the two is interposed a thin more or less continuous layer, which differs in lustre from, and contains more copper than, the original ore, and in appearance resembles *copper-pyrites*. * * *

"2*nd stage*.—This stage occurs at about the middle of the roasting process. The external appearance of the ore is the same as in the first stage, but the weight is much diminished. On breaking the lump across, several concentric layers may be observed. In the centre is a nucleus of unchanged ore, surrounded first with a layer similar in appearance to *copper-pyrites;* secondly, with a layer having a greater lustre and of a purplish colour, similar in appearance to *purple copper-ore;* thirdly here and there, with a layer having a metallic lustre and varying from the colour of *indigo copper-ore* to that of *vitreous copper;* lastly with a thick red-brown crust, forming the outer shell. * * *

"3*rd stage*.—On breaking across a lump of ore in this stage, which occurs when the roasting is nearly completed, a nucleus of unchanged ore can no longer be seen; but within the now greatly increased outer red-brown crust some yellow, reddish, and bluish particles may yet be perceived. * * *

"4*th stage*.—In this, the final stage, on breaking across a lump of ore it is found to consist only of a central nucleus having the appearance of *vitreous copper* or rather rich *copper regulus*, and an outer red-brown shell, not usually presenting any indication of concentric arrangement. * * *

"The kernels are separated by a few gentle blows with a hammer * * * and smelted for copper."

a Pennant, *Tours in Wales*, iii. pp. 61—3, 438—9, *Pl. XLIV.*; *Journal des Mines*, No. xvi. (1795) p. 70. Frère-Jean, *Annales des Mines*, xiii. p. 234—5.

b Percy, *Metallurgy*, i. (Lürzer, *Berg. u. hüttenmännisches Jahrbuch*, Tunner, 1853, 3, p. 339; & 1854, 4, p. 242) pp. 439,—44,—45. Haton, *Annales des Mines*, 5me Série, viii. pp. 426—34.

the total yield having been 126·75 tons of precipitate,

The rain-water—which occasionally percolates through this burnt rubbish—still bears with it to the precipitation-pits, notable quantities of the sulphate of copper.[a]

The waters which, for a century, have given,[b] and still continue to give,[c] such ample precipitates, aforetime—like the stream at *Dol-y-frwynog* in Merioneth[d] —deposited their riches in the turf,[b] through which they rose to the surface.[e]

The *Parys* and *Mona* mines now drain the surface so thoroughly, that—for want of fresh condensing-water—four, of their five, steam-engines are of high-pressure.

(1.) " The *Parys* mine emits annually about seven-hundred-million gallons of water impregnated with copper. This is collected in pits, into which is put old iron, which precipitates the copper. The average product of copper is from 55 to 60 tons ; and the iron consumed in obtaining this is 600 tons. The copper found in these waters, as indicated from the precipitate obtained, varies from 4 to 30 per cent., according to the wetness of the season; the sample I procured was during the dry season, and consequently rich in copper ; its specific gravity was 1·055 at 60° F. The solid contents of one gallon weighed 4,960 grains, which gave peroxide of iron 1,680 grains, oxide of copper 80 grains, sulphuric acid 3,040 grains, muriatic acid 38 grains, and 122 grains of earthy matters, which were not examined. In order to ascertain whether the copper might be extracted more cheaply by means of a galvanic current, or what is known as the electrotype process, than by the ordinary means of precipitation, a piece of iron, wrapped in a strip of brown paper, was attached to a piece of copper, and both were immersed in a solution of copper ore, in the muriatic acid, to be examined. The first action which took place, however, was the complete reduction of the persalt of iron to the state of protosalt, at the expense of the copper pole : after which the electric current began to effect its object, the copper being deposited, but from the copper which had been dissolved having also to be [precipitated], the consumption of iron was 658 grains, whilst the actual increase in weight of the copper pole was only 64 grains, the quantity of copper originally held in solution. * * * Different arrangements of batteries were tried ; platinum, silver and lead were also substituted for the copper, but in no case was a deposit obtained from the water until the iron was first brought into a state of protosalt; but when this was effected,

[a] Thomas Fanning Evans, Esq., of Mona Lodge, Amlwch, Superintendent of the *Mona* Mine and Smelting Works, MSS.

[b] *Ante*, p. 579, Note *a*.

[c] *Postea*, pp. 581—4, *Table XVIII. a*

[d] Henwood, *Reports of the Royal Institution of Cornwall*, xxxviii. (1856), p. 41. Ramsay, *Memoirs of the Geological Survey of Great Britain*, iii. p. 45.

[e] In the neighbourhood of Dôlgelley it is believed that the presence of copper in the soil, is indicated by the growth of the sea-pink or Thrift *(Statice Armeria)*, which flourishes in such spots with remarkable luxuriance.

and the proportion of copper during the period—

I obtained, by the method described 63 grains of copper by the loss of 53 grains of iron. * * *

"Both zinc and iron, when put into the persalts of iron, first reduce the persalt to the protosalt, which fully accounts for the great consumption of iron for the small [proportion] of copper obtained from these waste waters of mines, and not, as was generally supposed, from the existence of free acid; the copper is never all precipitated from the water so long as persalts of iron exist in the solution."

NAPIER, *Lond. Edin. & Dublin Phil. Mag.* xxiv. pp. 365—70 (abridged).

The following columns show the quantities of Iron consumed and Precipitate obtained, the respective proportions of the Precipitate and of the Fine Copper to the Iron consumed, and of the Fine Copper to the Precipitate, at the *Parys* mines, during the years 1862—6.

Years.	Quantities of: Iron in use. Tons (Av.)	Iron consumed. Tons (*Av.*)	Precipitate obtained. Tons (*Av.*)	Proportions of: Precipitate to Iron consumed.	Fine Copper to Iron consumed.	Fine Copper to Precipitate.
1862.	The quantity of Iron in use averaged from 900 to 1,000 tons.	568	363·8875	0·6406	0·1425	0·0911
1863.		599	327·2500	0·5463	0·1325	0·0723
1864.		611	296·7375	0·4857	0·1325	0·0644
1865.		418	284·8875	0·6887	0·1112	0·0766
1866.		550	271·1250	0·4929	·0·1425	0·0702
Totals.	—	2,746	1,546·8875	—	—	—
Means.	—	—	—	0·5633	0·1326	0·0746

MR. JAMES WILLIAMS, Accountant at the Mines, MSS.

(2.) At the *Mona* mine—

the copper-ores calcined from the beginning of 1832 to an early part of 1862 amounted to............ } 155,404 tons *(Avoir.)*;

but since that time they have been differently treated;—

the iron in use—reckoned annually—between 1832 and 1866, was, in the aggregate .... } 96,896 ,, ,, ;

of this the *(light-iron)* worn-out utensils whether of iron or tin-plate, and small scraps, indifferently of wrought or cast metal .... } weighed 61,973 ,, ,, ;

and the *(heavy-iron)* broken machinery and other heavy junks of either kind .. } ,, 34,923 ,, ,, ;

ranging from 0·1500 to 0·6537—having averaged, during the ten years, 0·4452 its weight.

the quantity of iron *consumed* during the same period	weighed	30,386	tons	*(Avoir.)*;
of which the *light-iron*..........................	„	24,087	„	„ ;
„ *heavy-iron*	„	6,299	„	„ ;
the *precipitate* collected	„	30,735	„	„ ;
the fine copper obtained	„	2,977	„	„ .

The following columns show the proportions of ore, iron, and copper, treated, consumed, and obtained, at various times and under different circumstances; *a* but *Table XVIII.*[a] mentions them in greater detail.

Periods.	Proportions of Iron consumed.	of Precipitate to Iron in use.	of Precipitate to Iron consumed.	of Fine Copper to Iron in use.	of Fine Copper to Iron consumed.	of Fine Copper to Precipitate.
1832—36	0·3228	0·3383	1·0482	0·0338	0·1048	0·0999
1837—41........	0·2978	0 3653	1·2267	0·0374	0·1256	0·1024
1842—46	0·2341	0 2472	1·0560	0·0288	0·1230	0·1164
1847—52 *b*	0·3196	0·3102	0·9703	0·0346	0·1082	0·1115
1853—57 *b*	0·3135	0·3414	1·0951	0·0239	0·0763	0·0697
1860—66 *b*	0·3990	0 3207	0·8036	0·0281	6·0704	0·0876
First fifteen years ..	0·2794	0·3092	1·1065	0·0328	0·1175	0·1067
Last sixteen years *b* .	0·3379	0·3251	0·9620	0·0290	0·0858	0·0892
Extremes Highest .	0·5048	0·4931	1·8803	0·0558	0·2072	0·1373
Extremes Lowest .	0·1715	0·2233	0·6505	0·0173	0·0549	0·0582
Means	0·3136	0·3175	1·0239	0·0308	0·0993	0·0969

a The annual fall of rain at the *Mona* mine has been

in 1861 .... 44·45 inches;	1864 .... 33·89 inches;
2 .... 40·14 „	5 .... 44·17 „ ;
3 .... 40·83 „	6 .... 42·23 „ .

THOMAS FANNING EVANS, ESQ., MSS.

b The Returns for 1850,—7,—8, & —62 are incomplete.

The broken machinery and worn-out tools used

Years in which	Proportions of Iron consumed.	of Precipitate to iron in use.	of Precipitate to Iron consumed.	of Fine Copper to Iron in use.	of Fine Copper to Iron consumed.	of Fine Copper to Precipitate.
the weight of iron *in use* exceeded an average..	0·2923	0·2975	....	0·0289	....	0·0973
fell short of „ ..	0·3517	0·3545	....	0·0342	....	0·0966
the proportion of iron *consumed* exceeded an average..	0·3783	....	0·9106	....	0·0874	0·0960
fell short of „ ..	0·2529	....	1·1004	....	0·1084	0·0985
the proportion of precipitate to iron in use exceeded an average..	0·3291	0·3841	....	0·0343	....	0·0894
fell short of „ ..	0·2958	0·2673	....	0·0280	....	0·1050
the proportion of precipitate to iron consumed exceeded an average..	0·2649	....	0·3765	....	0·1326	0·0964
fell short of „ ..	0·3428	....	0·8842	....	0·0863	0·0976
the proportion of fine copper to iron in use exceeded an average..	0·3153	0·3722	....	0·0340	....	0·1073
fell short of „ ..	0·3074	0·2817	....	0·0247	....	0·0877
the proportion of fine copper to iron consumed exceeded an average..	0·2671	....	1·1585	....	0·1279	0·1104
fell short of „ ..	0·3570	....	0·9157	....	0·0762	0·0832
the proportion of fine copper to precipitate exceeded an average..	0·3082	....	....	....	....	0·1114
fell short of „ ..	0·3357	....	....	....	....	0·0763

Of the ochre, which is continually formed, 17,833·06 tons *(Avoir.)* have been prepared for sale since 1860; namely—

in the precipitation works, comprise a much larger

1861 ...... 2,567·06 tons,	1865 ...... 2,016·98 tons,
2 ...... 2,061·92 ,, ,	6 ...... 3,175·84 ,, ,
3 ...... 2,232·81 ,, ,	7 ...... 3,286·15 ,, ,
4 ...... 2,492·30 ,, ,	

beside great quantities which escaped to the sea.

"The water from different parts of the mine, contains unequal proportions of, more than one, metallic salt; as the works are extended, indeed, they open at times springs of various qualities; generally speaking, however, the streams issuing from the great metalliferous deposit and from the quartzose rocks on the S., are more highly charged with the sulphates of iron and copper, than those flowing from the less siliceous slates, and from the smaller productive (beds) '*lodes*' which interlie them towards the N. Soon after the wet season sets in, the mine-water becomes more abundant, and the precipitate—increasing in some proportion to the rain—is, at the same time, both larger and richer than during any other period of the year. The proportion of solid matter contained in this water, as it flowed from the pump in February 1868, was about (0·0304 its weight) thirteen thousand four hundred and thirty-eight grains to the cubic foot.

"As precipitation takes place more slowly in cold, than in warm, weather; all mine-water is retained in tanks, and the works are suspended, during frost."

Thomas Fanning Evans, Esq., MSS.

(3.) At the *Devonshire Great Consolidated Copper Mines* [a] the water contains generally less than thirteen grains (about 0·00003 its weight) of copper to the cubic foot; a quantity too small to repay the cost of extraction. The streams which enter the shallower *levels* near the *Wheal Josiah* and the *Wheal Maria* shafts, are, however, more highly charged; but that of the former is—on its way to the surface—mixed with the less richly impregnated water from the deeper works. The following columns comprise both the elements and the results of the precipitation carried on, at these respective parts of the mines in 1866.

	Wheal Josiah.	*Wheal Maria.*
	QUANTITIES.	
Copper, grains of per cubic foot of water	29·15	48·02
,, precipitate, obtained, tons	17·00	12·00
,, fine, contained in the precipitate, tons	7·90	6·00
Iron in use, constantly maintained at, ,, ...	36·00	19·00
,, consumed.................... ,, ...	30·80	24·00
	PROPORTIONS	
Iron consumed .... to iron in use	0·4611	0·5581
Precipitate obtained ,, ...	0·2545	0·2791
Fine copper in precipitate ,, ...	0·1183	0·1395
Precipitate obtained to iron consumed	0·5519	0·5000
Fine copper in precipitate ,, ...	0·2565	0·2500
Fine copper in precipitate	0·4647	0·5000

[a] *Ante*, pp. 457—8, *Table XIV.*

proportion of cast, than of wrought, iron ; but especial

The quantity of water is smaller, but it contains a larger proportion of copper, in summer than in winter.

The iron is frequently dissolved by water which deposits no copper.[a]

Extracts from Official Records, by Mr. Isaac Richards, Accountant at the Mines.

(4.) At *Wheal Agar*—an abandoned mine near Crow's-nest in the Caradon district [b]—copper has been deposited for some years, by the *adit*-water in which the (Alga) *Mougeotia* thrives, even whilst it adheres to the precipitated metal.

The precipitate obtained is about 0·7500 the weight of the iron consumed,

the fine copper „ from $\left\{\begin{matrix}0{\cdot}2250\\ \text{to}\\ 0{\cdot}2625\end{matrix}\right\}$ „ „ ;

„ „ from $\left\{\begin{matrix}0{\cdot}3000\\ \text{to}\\ 0{\cdot}3500\end{matrix}\right\}$ „ the precipitate.

(5.) "About sixty years ago [the precipitation of copper by iron] was first observed by Mr. Coster in Chacewater Mine near Redruth; for after he had drawn out the water, which had been in the mine for several years, he found the poll of a pick-axe wholly encrusted with a case of malleable Copper between two and three pounds in weight. This it was justly supposed was observed by the workmen, some of whom afterwards settled at Cranbaun Mine in the county of Wicklow The water of Cranbaun having this vitriolic acid in a very high degree, Capt. Thomas Butler, who was one of Redruth, and manager of that mine, persuaded the proprietors to adopt the scheme of precipitating copper, of which they have made for many years past and now continue to make very con-considerable profit."—Pryce, *Mineralogia Cornubiensis* (1778), p. 231.

About 1830, some small parcels of copper, precipitated from the mine-water with lime at *Wheal Falmouth*, realized at the *ticketting* from £8 to £9 per ton.

James Treweek, Esq., of Chatham Lodge, sometime Manager of *Wheal Falmouth*, MSS.

(7.) *The Great* (Gwennap) *adit* extends its several branches in different directions between thirty and forty miles, through the most productive copper-district in Cornwall;[c] draining an area of five thousand five hundred and fifty acres; and discharging—after the drought of summer less than nine hundred, —after the rains of winter nearly two thousand nine hundred,—and on an average about fourteen hundred and fifty, cubic feet of water per minute.[c] This

[a] *Ante*, p. 580.

[b] *Postea*, pp. 620—30.

[c] Thomas, *Report on the Mining District from Chasewater to Camborne*, p. 28; *History of Falmouth*, p. 33. Henwood, *Phil. Mag. & Annals*, ix. (1831) p. 170, *Cornwall Geol. Trans.*, v. pp. 89*, 422—6.

account was not taken of the quantities. It is believed, however,

that the precipitate obtained was about (four-fifths) 0·8000 the weight of the iron consumed;
in which case
the copper must have been ,, ... 0·3562 ,, ,, .

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stream has, at different times, varied in temperature from 60°·5 [a] to 69°·25.[b] In August, 1867, a cubic foot yielded, on evaporation, seven hundred and thirty-five grains of residuum, which, for the most part, consisted of [c]

Iron.	Sulphuric acid.
Calcium.	Hydrochloric acid.
Sodium.	

with traces of other substances.[d]

It is a remarkable—and perhaps a characteristic—circumstance, that notwithstanding the *Great Adit* had been extended to the western boundary of *Poldice*, as early as 1768, by Mr. Williams; [e] and that, in the interval, a *side-drift* from it had been opened to the very *(Chacewater)* mine in which the precipitation of copper by iron had been observed about 1728[f] by Mr. Coster; no successful —if indeed any—attempt was made, to extract the water contained in the *adit*-water which had for so many years passed into the sea at Restronguet until late in the present century. In 1854, however, Mr. Richard Symons, of Twelve-Heads,—who had gained some experience in the mines of Cuba,—opened precipitation-pits on the stream, and the success of his operations stimulated his neighbours; in the course of eight or ten years, therefore, at least a dozen other parties had established themselves, on its banks, between Bissoe and Tarnon Dean, villages a mile and a quarter apart. As each of these is independent of every other, and as many of the partners in all are themselves the

a Henwood, *Cornwall Geol. Trans.*, v. p. 411.

b Fox. *Ibid*, iii. p. 316.

c Qualitative analysis by Mr. John Edgar Wright, A.A., of Penzance.

d One of the *Wheal Clifford* tributaries—which issued from the *lode* at a temperature of 125°—afforded per cubic foot of water, the undermentioned quantities of saline matter; namely—

Chloride of Lithium	1595·6	grains;
,, Potassium with a little Chloride of Cæsium	90·90	,,
,, Sodium	2,227·11	,,
,, Magnesium	54·27	,,
,, Calcium	1,324·04	,,
Sulphate of Calcium	75·15	,,
Silica	22·35	,,
Oxides of Iron, Aluminum, and Magnesium	in minute quantities.	
	3,953·38 grains.	

Miller, *Report of the British Association* for 1864, Part ii. p. 36.

e Henwood, *Cornwall Geol. Trans.*, v. p. 89*.

f Pryce, *Mineralogia Cornubiensis*, p. 231. *Ante*, p. 285.

The following comparisons

Mines and periods.	Rock.	Proportion of: Iron consumed	Precipitate to: Iron in use.	Precipitate to: Iron consumed.	Fine Copper to: Iron consumed.	Fine Copper to: Precipitate.	Precipitate to Water.
Connorree, 1838—9..	.... Clay-slate.	0·3226	0·3216	0·9969	—	—	0·00020000
1861—2..	....	—	—	0·4800	0·2100	0·4400	—
Cronebane, 1862	Clay-slate.	—	—	0·4000	0·1400	0·3500	—
Ballymurtagh, 1852—6..	.... Clay-slate.	—	—	0·8000	0·3562	0·4634	—
1857—61.	....	—				0·4207	—

workmen; it has been found impossible to obtain full particulars of their operations.

In each series of *(strips)* pits
the iron in use is commonly maintained at .... 4 or 5 tons,
and by the consumption of .... from 2 to 2½ „
a precipitate of .... about.... 1 ton
is obtained.[a]

The precipitate collected, has, for some time past, ranged from eighty to one hundred, and averaged about ninety, tons a year.[b]

The proportions of fine copper it has afforded at different times are shown in the following columns:—

Years.	Highest	Lowest.	Average.
1864	0·6162	0·1500	0·3329
5	0·5875	0·1200	0·4054
6	0·5875	0·1200	0·3703
7	0·6150	0·0625	0·4037
Extremes	0·6162	0·0625	—
Mean	—	—	0·3900

Howard Bankart, Esq., Managing Partner of the Red Jacket Copper Works, Briton Ferry, South Wales, MSS.

a Mr. John Ninness of Twelve-Heads; a Proprietor of Precipitation-works.

b Henry Williams, Esq., of Alma near Truro, Sampler and Shipping Agent of Messrs. Vivian.

show that the water now yields smaller proportions of copper than it formerly yielded.

The proportions of the results obtained are,—

	to Iron in use.	to Iron consumed.	to Precipitate.
Iron consumed	0·4000—0·6250		
Precipitate	0·2000—0·2500	0·4000—0·5000	
Fine Copper	0·0125—0·1540	0·0250—0·3081	0·3900

Taking, therefore,—

the average discharge of the adit [a] .... at 1,450 cubic feet per minute;
,, quantity of saline matter contained in the water [b] ...... ,, 735 grains per cubic foot;
,, ,, precipitate obtained [c] .. ,, 90 tons per annum;
,, proportion of fine copper contained in the precipitate .. ,, 0·390 its weight;

the salts amount to .... about 0·001220 the weight of the water;
,, precipitate amounts to.......... ,, 0·00000423 ,, ,, ;
,, fine copper ,, ... ,, 0·00000165 ,, ,, ;

that is to say, 423 parts of precipitate containing 165 ,, fine copper } are extracted from 100,000,000· parts of water.

or (three thousand seven hundred and eighty-four cubic feet) .... } one hundred and five tons of water yield about one pound of precipitate;
,, (nine thousand six hundred and ninety-three cubic feet) .. } two hundred & seventy ,, ,, ,, ,, of fine copper.

The foregoing approximations—although as close, perhaps, as our present means of information permit—make no pretension to *minute* accuracy; they show, however, the remarkable means by which many industrious families earn a comfortable livelihood.

The precipitate is both richer and more abundant, in winter than in summer; and at all seasons it is of better quality in the upper, than in the lower, part of the stream. When tinned iron is used as a precipitant, the deposit obtained affords metal of much the same kind as that smelted from *tinny* copper-ore.

In this water,—as in that of *Wheal Agar*, [d]—the (Alga) *Mougeotia* flourishes.

Although the several tributaries of the *adit* rise in the Parishes of Redruth, Kenwyn, and Gwennap, the owners of land abutting on lower parts of its stream, in Kea, Feock, and Perran-ar-worthal, claim (Royalty) *Dues*—in two or three cases of one-tenth, but generally of one-fifteenth—of all precipitate collected in pits opened on their respective freeholds.

(8.) "The water issuing from the adit at *Tresavean*, often yields a copious

[a] Thomas, *Cornwall Geol. Trans.*, v. p. 422. Henwood, *Ibid*, p. 423. *Ante*, p. 586.
[b] *Ante*, p. 586. [c] *Ante*, p. 587, Note *b*. [d] *Ante*, p. 585.

At *Ballygahan* precipitation has long been discontinued.

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precipitate; though sometimes it dissolves the iron immersed in it, yet deposits but little copper instead.[a] The precipitate contains from 0·10 to 0·30 its weight of pure metal." CAPTAIN THOMAS BLAMEY, of Lanner near Redruth, MSS.

(9.) "Experiments have been made lately on the water which flows from the *adits* of *Dolcoath, Cook's-kitchen, Wheal Crofty,*[b] and *North Roskear,*[c] but with little success; nor, in fact, has any copper, worth notice, been observed in the calcareous sand[d] through which it escapes into the sea at Gwithian."
WILLIAM COCK VIVIAN, ESQ., of *North Roskear,* MSS.

(10.) "The following description of the process of cementation applies generally to the mines of the province of Huelva.[e] The ore is first calcined, in heaps, varying in dimensions; a common measurement for the base of the truncated pyramid is 12 metres by 7 metres [39·3 by 23·0 feet]; the usual height is about 1 metre [nearly 3·3 feet]; such a heap contains about 4,000 quintals [181 tons *Avoir.*). The cost of calcination * * *, labour and fuel included, was, in 1859, 36 cents per quintal of ore, equal, to 1*s.* 7$\frac{3}{4}$*d.* per ton. The time required to complete the operation is from five to six months. The heaps are open to the air, and have no covering of any sort. * * * The ore is said to lose about 20 per cent. of its weight in the operation of calcination.

"The calcined mineral is [conveyed] to the lixivation tanks, [which] are generally constructed of rough masonry, and lined with asphalte; their dimensions vary considerably, but the most common size is 7 metres long by 4$\frac{1}{4}$ wide and 1 deep [23·0 × 14·2 × 3·3 feet]. They are two-thirds filled with ore, and contain about 2,000 arrobas, say 23 tons nearly. The length of time the ore is allowed to remain in the tanks varies in different establishments; it depends on the quality of the ore, and the greater or less perfection of the calcination. At Rio Tinto from seven to nine days usually suffice, but at La Chaparita twelve days [are sometimes required]. The waters are drawn off and renewed as often as necessary; the first water is saturated in two or three hours, the last is left as many days.

"From the lixivation tanks the water, charged with salts of iron and copper, passes to those of cementation; the latter being of nearly the same form and dimensions as the former. In them are placed pieces of pig iron forming squares.

"During winter it is found necessary to agitate the water to accelerate the precipitation of the copper, but during the hot season this is not much practised.

a Napier, *London, Edin., & Dublin Phil. Mag.*, xxiv. pp. 365,—70. *Ante*, pp. 580—1.

b Pryce, *Mineralogia Cornubiensis*, p. 232.

c Thomas, *Ante*, p. 354, Note ‡

d Henwood (Pepper's *Play-book of the Metals*), p. 275.

e *Ante*, pp. 543—6.

The vale of Ovoca was long celebrated for the

When the solution has been sufficiently impoverished it is drawn off into a third tank, and left to deposit the subsalts of iron held in suspension; the resulting precipitate is found to contain 10 per cent. of copper and a good deal of arsenic. After the solution has been drawn off from the cementation tanks, the pigs of iron are freed from the copper adhering to them, and the precipitate is collected. This assays about 55 per cent. for copper, and varies from 50 to 60 per cent.

"The iron consumed in cementing at the Rio Tinto mines for the year 1859 was 2·17 to 1 of copper.

"The quintal of calcined mineral costs for expenses of lixivation and cementation 1 real 72 c. or $4\frac{1}{4}$*d.* nearly." [7*s.* $9\frac{3}{4}$*d.* per ton *Avoir.*]

Thomas, *Notes on the Mines of Rio Tinto*, pp. 14—16; *Mining and Smelting Magazine*, I. p. 116.

(11.) "At the *Lucençia* mines, near Valverde in the same Province, the mine-water is passed through heaps of calcined ore on its way to the pits; in which a precipitate, containing from 50 to 60 per cent. of copper, is obtained by the consumption of four or five times its weight of pig-iron."

The precipitate is, therefore,	from	0·20 to 0·25	the weight of the iron consumed;
,, fine copper	,, ,,	0·10 ,, 0·15	,, ,, ,, ;
,, ,,	,, ,,	0·50 ,, 0·60	,, precipitate obtained.

Frederick Bankart, Esq., of Langley Lodge, Herts, MSS.

(12.) Precipitation—established in Cuba by me during 1844—was carried on at the *Santiago* [a] mines in a series of tanks and *launders.*

Each of the first three tanks was	12 feet long,	6 feet wide,	and	6 feet deep;
,, second three ,, ,,	12 ,, ,,	6 ,, ,,	and	4 ,, ,, .

As the surface had but a slight slope, each tank was divided crosswise to within a foot of the bottom, in order that the water might descend on one side of the partition, ascend on the other; and, at length, pass off through *launders,* about two feet in width, and a foot in depth.

In each compartment of every tank three or four wooden racks were laid with wrought iron bars, and the *launders* were supplied with scraps of iron. The weight, of both sorts, in use was maintained at about one hundred tons. The water—in time of drought as little as ten,—during rain as much as one hundred and fifty,—and on an average perhaps (3·2653 cubic feet) twenty, gallons per minute—filtrated through heaps of *(halvans)* inferior ore, the refuse of several previous years, on its way to the tanks.

Bar-iron, direct from the Manufacturer, extracted from water of good strength	about	1·2000 its weight of precipitate;	
,, of like quality, threw down, from water of less strength,	,,	its own weight	,, ;
but small scrap, and rusty, iron, separated from weaker solutions	,,	0·7770	,, .

a Ansted, *Journal of the Geol. Soc.*, xii. pp. 144—53. *Ante*, p. 441, *Table XIV.*

variety and beauty of its scenery; but the railway

The precipitate contained in but a single instance less than 0·7000 its weight of fine copper;
„ „ in another case as much as .... 0·8950 „ ,
„ „ on an average .... 0·7500 „ .
The mean monthly returns of precipitate were about five tons.

JAMES TREWEEK, ESQ., sometime Superintendent of the *Royal Santiago Mines*, MSS.

Now if
the quantity of water amounted to (20 gallons) 3·2653 cubic feet per minute,—
„ precipitate „ .... 5· tons per month,—
and the precipitate yielded .... 0·7500 its weight of fine copper;
the water must have afforded 0·00125297 its weight of precipitate,
& „ „ 0·00093973 „ fine copper.

One pound of precipitate was, therefore, obtained from (12¾ cubic feet) 798 lbs. (0·36 ton) of water;
„ fine copper „ „ (17 „) 1,064 „ (0·47 „) „ ;
this water must consequently have been more than five hundred times as rich in copper as the stream of the *Great* (Gwennap) *Adit* is at present.[a]

(13.) "When the *Cobre*[b] mines were in full work, they afforded from sixteen to eighteen tons of rich precipitate per month for many years. * * * But since underground operations have been confined (almost exclusively) to the deep *levels*, where the ore consists altogether of hard compact copper pyrites, the quantity of precipitate obtained has been much reduced; and, with the present diminished scale of operations, it probably does not exceed five or six tons per month, whilst the quality is very inferior."—JOHN PETHERICK, ESQ., F.G.S., Consulting Engineer of THE COBRE MINING COMPANY, MSS.

During 1854,—5,—6, and 1864,—5,—6, respectively, the undermentioned quantities and qualities of precipitated copper from the *Cobre* mine, were sold at Swansea:—

Years	Quantity of Precipitate. Tons (*Avoir.*)	Proportion of Fine Copper in Precipitate.		
		Highest.	Lowest.	Mean.
1854	244	0·7737	0·6100	0·6891
5	235	0·7462	0·4500	0·6745
6	193	0·7700	0·5300	0·6504
Total	672	—	—	—
Extremes	—	0·7737	0·4500	—
Mean	—	—	—	0·6736
1864	180	0·7225	0·3500	0·6298
5	163	0·7100	0·4750	0·5628
6	278	0·7500	0·3750	0·6300
Total	621	—	—	—
Extremes	—	0·7500	0·3500	—
Mean	—	—	—	0·6123

JOHN WILLIAMS, ESQ., Agent at Swansea for THE GOVERNOR AND COMPANY OF COPPER MINERS, MSS.

a *Ante*, p. 588. b *Ante*, p. 441, *Table XIV.*

and mine-works have destroyed much of its surface and poisoned most of its water.

RECAPITULATION.

Mines.	Rocks.	Proportions of Iron consumed	Proportions of Precipitate to Iron in use.	Proportions of Precipitate to Iron consumed.	Proportions of Fine Copper to Iron in use.	Proportions of Fine Copper to Iron consumed.	Proportions of Fine Copper to Precipitate.	Proportions of Precipitate to Water.	Proportions of Fine Copper to Water.
Wales.									
Parys	Clay-slate.	0·5070	0·3250	0·5633	—	0·1326	0·0746		
Mona	,,	0·3136	0·3175	1·0239	0·0328	0·0993	0·0969		
Devon.									
Consols { *Wh. Josiah.*	,,	0·4611	0·2545	0·5519	0·1183	0·2565	0·4647	—	0·00006600
Consols { *Wh. Maria.*	,,	0·5581	0·2791	0·5000	0·1395	0·2500	0·5000	—	0·00011000
Cornwall.									
Wheal Agar	Granite.	—	—	0·7500	—	0·2438	0·3250		
Tresavean	,,	—	—	—	—	—	0·2000		
Great Adit	Granite, Slate, & *Elvan.*	0·5125	0·2250	0·4500	0·0832	0·1665	0·3900	0·00000423	0·00000165
Spain.									
Huelva	Clay-slate.	—	—	0·4608	—	—	0·6750		
Lucençia	,,	—	—	0·2250	—	0·1250	0·5500		
Cuba.									
Santiago	Porphyry.	—	—	1·000	—	0·4500	0·7500	0·00125297	0·00093973
Cobre	,,	—	—	—	—	—	0·6123		

The *Knockmahon* Mine, immediately E. of Bonmahon, in the county of Waterford,* has been wrought both inland and beneath the sea in rocks of the Silurian system, on several *lodes.*

(*a.*) The metalliferous slates range nearly N.E.—S.W.; and dip towards the S.E. at various—but always at low—angles. Their cleavage—though sometimes regular—is mostly uneven; and—whilst occasionally flecked with some pearl-white substance—they are generally homogeneous, In S.E. and central parts of the mine, their prevailing tints vary, from greenish and bluish black to greyish green; but towards the N.W. they are of coal-black hue.† Massive rocks of

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* "Tradition tells of ore having been raised from Knockmahon in the reign of Elizabeth and at other periods down to 1730, when a Mr. Hume worked profitably the Stage lode for a length of time. In 1796, and some years subsequently, Colonel Hall and Mr. Galway spent a large sum on various parts of the ground unsuccessfully. It then passed into the hands of the Hibernian Mining Company, and in 1824 became the property of the Mining Company of Ireland, who have prosecuted the workings continuously to the present time [1863] with varying success; * * * .

"Seven steam-engines and six water-wheels assist in the general operations. * * * The water-power is principally derived from the River Mahon, being brought to the dressing-floors by an artificial cut three miles in length; * * *.

"The ore is shipped off to Liverpool and Swansea by vessels that (weather permitting) come close in shore; there being no harbour nearer than Dungarvan or Waterford."

Hore, *Explanation to accompany Sheets* 167, 168, 178, *and* 179 *of the Maps and Section* 13 *of the Geological Survey of Ireland*, p. 81.

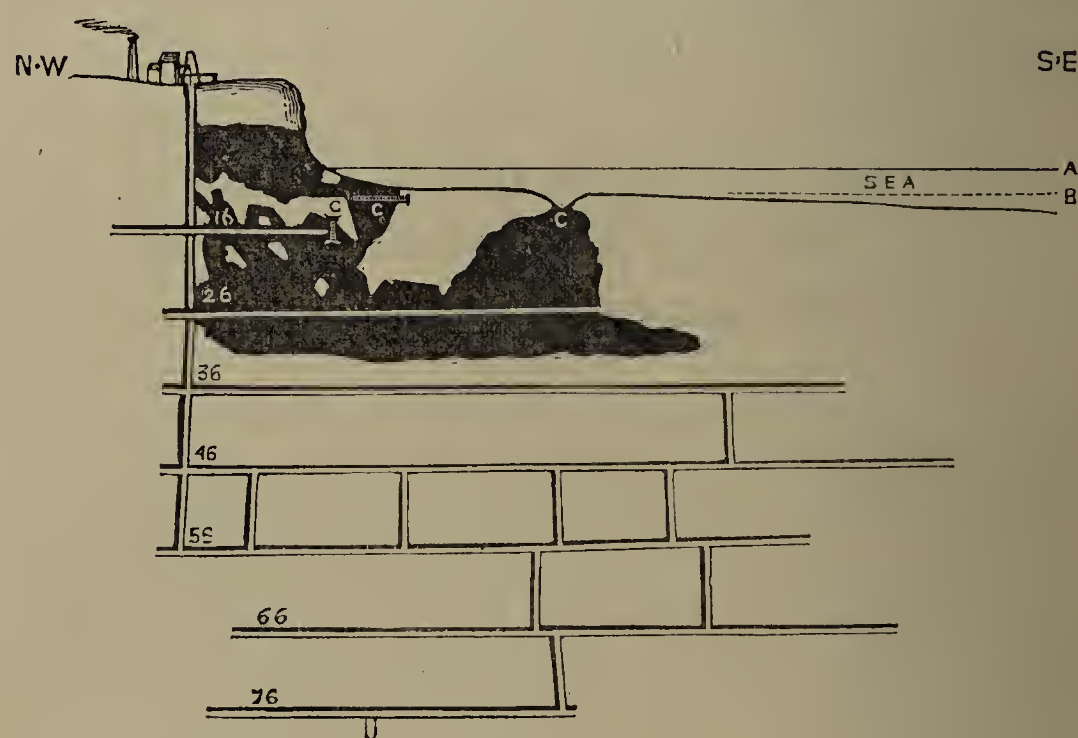
† "The eastern portion of the county of Waterford consists almost entirely of clay slate. * * * In the vicinity of Bonmaghon, copper mines were formerly worked to some extent."—Weaver, *Geol. Trans*, v. p. 248.

"In the extreme S.W. corner of the townland of Tankardstown, * * * we enter on a mass of gray slates interstratified with some beds of greenish-gray feldspathic ash, which are traversed from N.W. to S.E., or across their general strike, by five of the most productive of the Knockmahon copper lodes. * * * This brings us into the townland of Knockmahon, the western portion of which is formed of alternate bands of pale greenish-gray felstone, hard gray ash

felspar and quartz are exposed in several of the works; and a well-defined bed of felspar and hornblende approaches the black slate near the Mahon.

(*b.*) Several of the *lodes* and many of their *branches* crop out in the cliff;* and some of them are worked beneath the sea.

Fig. 31. KNOCKMAHON MINE, COUNTY OF WATERFORD.
Longitudinal section of the *Stage lode.*



Scale 40 fathoms to the inch.

a. Level of high-water at half-spring.

b. ,, low-water ,,

c c c. Artificial *dams*, built to prevent irruptions of the sea through openings accidentally made from below.

(sometimes containing thin layers formed of broken-up fragments of trilobites, encrinites, and small cup corals), and earthy gray slate, forming a portion of the same series of rocks just noticed and traversed like them from N.W. to S.E. across their strike by the Old Stage Lode and its numerous branches, and at the western extremity of the townland by four minor lodes. In the extreme N.W. corner of the townland we find a thin dyke of greenstone overlaid by a felspathic ash and a layer of purplish brown grit dipping to the S.E. at 20°."

DU NOYER, *Explanations to accompany Sheets* 167, &c., *of the Geological Survey of Ireland*, p. 57.

* "The Tankardstown lode, the most eastward of all the lodes at Knockmahon,

Their directions and dips are much the same as those

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* * * strikes N.W. for half a mile from the coast, when it strikes to the N.N.W., and has been worked at detached localities for a further distance of half a mile. It inclines to the S.W. at angles varying from the horizon from 52° to 68°. Seawards, this lode has been profitably worked for the distance of 250 yards from the shore.

"Rowe's lode appears in the cliff at the distance of 60 yards to the west of Tankardstown lode, which it joins inland at the distance of 125 yards. It occurs on the line of a fault, and strikes N. & S. with an inclination of 70° to the west. At the junction of these two lodes the solid copper-bearing lode was nearly 70 feet in width, decreasing, however, rapidly to 4 feet as it was followed on the strike of the greater lode.

"Boneyaught lode [which succeeds Rowe's] has been traced along a line of fault in a direction of N. 10° to 15° W. for the distance of half a mile from the coast, with an inclination of 50° to the eastward, but it has not been worked beneath the sea.

"Sixty yards [from] Boneyaught lode is the Kilduane lode, the general strike of which is N.N.W. from the coast with an inclination of 50° to the eastward: it, or a lode resembling it, has been followed inland for about a mile.

"A hundred yards to the west of this lode is the Seven Dials lode, which has much the same strike and inclination.

"All these lodes occur in gray slate as well as in the feldstone, crossing the bedding at right angles.

"At the distance of 350 yards west of the Seven Dials lode is the Old Stage lode, with its numerous branches and strings, discovered close to the coast. * * * The strike of the Stage lode is about N.W., the "*hade*" being variable, but generally vertical. When the "red ground (the red conglomerate and shale in the Silurian rocks) was reached under the crushing floors of the mine the lode was lost, but it is supposed that to the north of these beds, under the name of the North Mine lode, it was recovered, and it has been worked for over three-quarters of a mile through the porphyritic feldstone into the townland of Ballynasissla. Here the lode was again lost where the black slaty band on the north was reached, but by furtheroperations in the neighbourhood these black slates were found to contain copper in workable quantities, disseminated throughout them in strings, and filling up small cracks and fissures."

Du Noyer, *Explanations to accompany Sheets* 167, &c., *of the Geological Survey of Ireland*, pp. 81—2. (Abridged.)

"A remarkable fossiliferous locality occurs on the shore, close under the engine-house of the Knockmahon copper mines, which Mr. Du Noyer describes as an "ash bed:" it is a hard bluish gray rock, characterized by bands of the variety of *Stenopora fibrosa*, called *lycoperdon*, which stand out from the rock where exposed to the sea action like nodular concretions, until on a closer examination they are found to be corals. * * * The fine Brachiopod *Orthis crispa*, so frequently occurring throughout this district, is also plentiful here: an uncommon Gasteropod shell *Raphistoma elliptica;* and the Trilobites *Phacops Brongniarti* and *Asaphus gigas* have also been collected at this place."

Baily, *Ibid*, p. 24.

maintained by the *lodes* of the St. Just district,* by the *Caunter lodes* of West Cornwall,† and by some of the *lodes* in *Bearhaven*.‡

The following columns afford comparisons of the directions and dips of the *North Mine* and *Stage lodes* with the direction and dip of the rocks; as well as of the dimensions of one *lode*, to a depth of forty-six fathoms, with those of the other from sixty-six to ninety-six fathoms from the surface.§

Lodes and Rocks.	Directions.	Dips.	Depths: fms.	Sizes: feet.
North Mine Lode......	38°—45° W. of N.—E. of S.	N.E. 20°—70°.	Surface to 46	8—30
Stage Lode	38°—45° W. of N.—E. of S.	N.E. 60°—S.W. 60°.	66—96	1—15
Cleavage of the slates‖..	N.E.—S.W.	S.E. 10°—40°.		

Both the *lodes* contain many masses of slate, of various sizes, but, in composition, they are all identical with the rocks respectively adjoining. Some of them lie imbedded in clay; but by far the greater numbers are enveloped in, and transfused with, siliceous matter,

* Carne, *Cornwall Geol. Trans.*, II. p. 321. Henwood, *Ibid*, V. p. 250, *Table CIII.*

† Hitchins, *Phil. Trans.*, XCI. pp. 159—64. William Phillips, *Geol. Trans.*, II. pp. 146—52. Thomas, *Survey of the Mining District from Chasewater to Camborne*, p. 19. Carne, *Cornwall Geol. Trans.*, II. pp. 105, 321. Burr, *Mining Review*, No. VIII. (1836) p. 210. Fox, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 83. De la Beche, *Report on the Geology of Cornwall*, &c., p. 365. Henwood, *Edin. New Phil. Journal*, XXII. p. 159; *Cornwall Geol. Trans.*, V. p. 253.

‡ Smyth, *Explanation to accompany Sheets* 191, 197, *&* 198 *of the Geological Survey of Ireland*, p. 31. *Postea*, p. 611.

§ *Table XIX.*

‖ Du Noyer, *Explanations to accompany Sheets* 167, 168, 178, *&* 179 *of the Geol. Survey of Ireland*, p. 56.

mixed with smaller proportions of chlorite and calcareous spar; whilst all are veined with quartz. Small quantities of earthy brown iron-ore occur near the surface, and iron-pyrites is common at greater depths. Malachite, earthy black, and vitreous, copper, and other rare ores of the same metal, are sparingly scattered through shallow parts of the matrix; but in both *lodes* copper-pyrites prevails.*

Longitudinal joints divide the *lodes* into subordinate (slices) veins; some of which exhibit, at intervals, characteristic differences of composition.

The masses *(bunches)* of ore—declining † from the great felspathic formation ‡ on the N.W., N., and N.E., as the slates also decline; ‡ yet conforming to

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* At the depth of 100 fathoms the *Tankardstown lode* presented a productive width 40 to 60 feet, and in some places more than this, all the stuff yielding yellow copper ore of remarkable purity."—Du Noyer, *Explanations to accompany Sheets* 167, 168, 178, *&* 179 *of the Geological Survey of Ireland*, p. 81.

" On one part of the *Tankardstown lode* three *levels* were *driven* abreast at the same time, through copper-pyrites; bodies of similar ore being, for a while, left standing between them."

Captain James Clemes, Manager of *Knockmahon*, MSS.

† Henwood, *Edin. New Phil. Journal*, xxii. p. 157; *Cornwall Geol. Trans.*, v. pp. 51, 54, 87*, 129,—93.

" The quartziferous porphyry consists of small crystals of flesh-coloured felspar and quartz, embedded in a paste which I imagine to be essentially aluminous; with the aid of a powerful glass, minute cubes of iron pyrites are seen, which, with the felspar and quartz, are the only crystalline substances. This formation is rather extensive on the line of coast to the east of Bonmahon Bay, and is also found cropping out on the sides of several low ranges of hills, and even obtaining a considerable altitude in more than one place inland."

Holdsworth, *Journal of the Geological Society of Dublin*, i. p. 88.

Geological Survey of Ireland, Sheet 178.

Du Noyer, *Explanation to accompany Sheets* 167, 168, 178, *&* 179 *of the Geol. Survey of Ireland*, pp. 56—9.

‡ Weaver, *Geol. Trans.*, v. pp. 140—185. Boase, *Cornwall Geol. Trans.*, iv. p. 432; *Treatise on Primary Geology*, p. 119.

the schistose structure of the neighbouring rocks,*—as in other localities the *shoots*, as well of similar as of different† ores also conform—dip endlong towards the S.E.

(*c.*) The directions, dips, and sizes of the *cross-(flucans) veins* are

Cross- (flucans) veins.	Directions.	Dips.	Widths: feet.
North Mine flucan	20°—25° E. of N.—W. of S.	N.—N.W. 70°—76°.	1.
Stage flucan..........	40°—42° E. of N.—W. of S.	S.E. 70°.	0·5—3.

They consist, for the most part, of slaty clay and disintegrated felspar; enclosing, however, many spheroidal masses of quartz.‡

(*d.*) The *North Mine flucan*—

at 16 fms. deep is a single *vein*; .... which *heaves* the *North Mine lode* 46 fms.;
,, 46 ,, ,, forms three distinct *branches*; each of which *heaves* the same *lode*, the sum of their *heaves* amounting to .. 25 ,, .

The *Stage Mine lode*—

at 86 fms. deep intersects the *Stage lode* .... and *heaves* it 4 feet;
,, 96 ,, ,, intersects a *branch* of the same *lode* .... but does not *heave* it.

In both cases, however,—as in more than one-half the displacements of copper-*lodes* by *cross-veins* in Cornwall§—the *heaves* are to the Right-hand and towards the side of the Greater-Angle.

(*e.*) Between twenty and thirty-six fathoms from the surface, a *(Slide)* vein of slaty clay scarcely an inch in

* Tregaskis, *Report of the Royal Cornwall Polytechnic Society*, IV. p. 95. *Ante*, p. 207. *Postea*, p. 613.

† Henwood, *Cornwall Geol. Trans.*, V. pp. 41, 24, 87, 129,—93; VI. p. 146; *Ante*, pp. 32, 207,—63,—4,—83, 382, 439, 535,—7,—78, *Postea*, p. 613.

‡ Henwood, *Cornwall Geol. Trans.*, V. p. 262, Note.

§ *Ibid*, pp. 286—7, *Table CVII.*

width,—having nearly the same direction as the *North Mine lode* but an opposite dip,—occasions a *(leap* or *throw)* vertical displacement of about sixteen fathoms (upward) towards the side of the Greater-Angle.*

On the *Stage lode* a rich *bunch* (shoot) of ore was followed in several *levels*—as it dipped endlong—to-towards the S.E.; not only beneath the beach,—of which a breadth of fifty fathoms is left dry at low-water,—but, beyond it, for at least one hundred fathoms under the sea. At the depth of one hundred and six fathoms, in fact, the works have been extended fully one hundred and fifty fathoms from the cliff, which, at half-spring tide is washed by the sea at high-water.†

For some time, however, the shallower works were

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* The interferences of copper-*lodes* with *slides* "present either simple intersections, or *leaps* downwards towards the greater angle."

Henwood, *Cornwall Geol. Trans.*, v. p. 332.

† "The shaft N. of the Old Stage was sunk 212 fathoms, and in driving on this lode, seawards, several *runs* took place from the works having been carried on too close to the sea floor, and at the distance of about 350 yards from the coast the sea broke into the mine some years since, and great difficulty was experienced in staunching the break. The works on this lode have been carried on beneath the sea to the distance of about 500 yards from the coast line."

Du Noyer, *Explanation to accompany Sheets* 167, 168, 178 *&* 179 *of the Geological Survey of Ireland*, p. 82.

The undermentioned mines in West Cornwall are still wrought beneath the sea;—

"At *Wheal Margery* near St. Ives the 120-fathom *level* extends 121 fathoms from the shore."—Captain Richard James, Manager of *Wheal Margery*, MSS.

"At *Levant* in St. Just the 150-fathom *level* has been *driven* 299 fathoms beneath the sea."—Captain J. Nicholas, Manager of *Levant*, MSS.

"At *Botallack* in St. Just the 115-fathom *level* extends 384 fathoms seawards from the base of the cliff."

Stephen Harvey James, Esq., Manager of *Botallack*, MSS.

"At Whitehaven certain seams of coal, remarkable for their thickness and regularity, are worked by Lord Lonsdale along a coast line of nearly 2 miles to the distance of $1\frac{1}{4}$ mile under the sea.

Smyth, *Treatise on Coal and Coal Mining*, p. 50.

conducted so incautiously, and the crust of vein-stone left standing between them and the strand was so thin, that

at eight fathoms from the cliff, in the *back* of the sixteen-fathom *level*,
,, thirty ,, ,, ,, twenty-six- ,, ,,

the sea found its way into the mine, but,—with great difficulty and at a great expense—it was, in both places, successfully dammed out.*

* " In *Little Bounds*, *Botallack*, and *Wheal Cock* the ore was followed upward even to the sea; but the openings made were very small, and the rock being extremely hard, a covering of wood and cement in the two former, and a plug in the latter sufficed to exclude the water, and protected the workmen from the consequences of their rashness."—Carne, *Cornwall Geol. Trans.*, ii. pp. 339, —41,—43. Henwood, *Ibid*, v. p. 10.

" At Workington the seams worked beneath the sea * * * were followed up too far, and as due precaution was strangely disregarded, the sea burst in in 1837, and the lamentable result was the loss of thirty-six human lives, and the entire destruction of the colliery."—Smyth, *Coal and Coal-Mining*, p. 51.

In April, 1840, the imprudent removal of a prop *(stull)* caused many thousand tons of rubbish to fall on Michael Walsh of Bonmahon, one of several miners engaged at the sixty-six fathom *level*, beneath the sea. Although little or no hope of his safety remained, a strong party was instantly employed, as well to extricate the body that it might be decently buried, as to re-open the drift and repair the damage. After the men had worked some twenty-four hours, however, they were astonished to hear the voice of their lost comrade, who was shut in by masses of the fallen rocks. He told them that his knees almost touched his chin,—that salt-water had risen nearly to his mouth,—and that he had eaten his last candle. Relays of the ablest workmen were immediately told off for the duty; but, from the narrowness of the *level*, more than one of them was seldom able to work at a time. Notwithstanding the displacement of every stone occasioned some—and often dangerous—movement in the mass, men were bold enough to worm themselves through the crevices, but they were unable to reach him; before the lapse of a second day, therefore, it was evident that there was no hope of his immediate rescue, and, at intervals, he became delirious. About this time an English Churchman present, suggested that the sufferer might probably be comforted by a visit from his Clergyman. This hint was at once reported to the Reverend James Power, R.C. Priest of the Parish, who, without hesitation, descended the mine, and administered the consolations of Religion to him as he lay. Some hours later the work had so far advanced, that small quantities of food were occasionally passed to him through openings between the stones, and about the end of the third day he was set free. His limbs, of course, were cramped from the straitened position in which he had been con-

Some of the slates are interstratified with beds of conglomerate;* but, as these are unproductive within the area to which this memoir refers, a description of them is beyond its scope.

Other rich *lodes* have been, from time to time, worked in *Knockmahon*, but the writer has had no opportunity of examining them.

The mine afforded, from the beginning of 1825 to the end of 1865,

Copper-ores which realized .... £1,399,232†

The expenditure on salaries, wages, & materials	... amounted to	£855,621	
,, Royalties *(Dues)*	,,	54,458	
,, Profit, divided amongst the Shareholders. ...	,,	489,153	£1,399,232.

The coast—presenting alternately caverned cliffs and sandy beaches—resembles the wildest and most desolate shores of West Cornwall.‡

fined, he was benumbed by long immersion, and weak from fasting; but otherwise he was unhurt. A weary time passed before his recollection returned; and he recovered his strength slowly: he never resumed his place underground; but he is still (1868) employed on light jobs at the surface.

* "In the townland of Ballynagigla, we find some beds of reddish conglomerate and reddish-purple shale interstratified with a grey feldstone * * * when the 'red ground' (the red conglomerates and shales of the Silurian rocks) was reached, under the crushing floors of the mine, the lode was lost, but it is supposed that to the north of these beds, under the name of the North Mine lode, it was recovered."—Du Noyer, *Explanations to accompany Sheets* 167, 168, 178, *&* 179 *of the Geological Survey of Ireland*, pp. 57, 82.

† Robert Heron, Esq., Secretary of the Mining Company of Ireland, MSS. *Ante*, p. 442, *Table XIV.*

‡ Henwood, *Cornwall Geol. Trans.*, v. pp. 42, 113,—30.

The Bearhaven Mines are wrought, at the head of Ballydonagan-bay near the western extremity of Cork, in rocks composed of siliceous matter mixed with chlorite,* talc, or some kindred mineral; traversed by microscopic veins of quartz; and sprinkled, at intervals, with the carbonate of lime. Such portions of them as adjoin rich parts of the *lodes*, are, in general, pale-buff, lilac, or dove-coloured, and of thick lamellar structure; but elsewhere they are blue and fissile.† The planes of cleavage—although in some places considerably curved—are, on the whole, nearly parallel to the *Main lode* in direction; yet—maintaining a much higher inclination than it maintains—they dip sometimes towards one side, sometimes towards the other, but mostly towards the north.‡ The lilac, buff-coloured, and blue slates alternate, here and there, with narrow

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* "A mineral allied to chlorite, and seemingly that called an hydrous mica by Dana, is found abundantly in the quartz veins."—Kinahan, *Explanations to accompany Sheets* 197, *&* 198 *of the Geological Survey of Ireland*, p. 29.

† "The dark blue varieties of the clay slate are considered by the miners unfavourable to the production of copper ores, whilst the gray, and particularly the buff kinds, as in Cornwall and elsewhere, are held to be congenial."

Smyth, *Ibid*, p. 30.

"In the two carboniferous troughs of Kenmare and Bantry * * * the rocks consist of red, purple, brown, and greenish sandstones, sometimes becoming purplish grey, but never black or dark-grey, and they are variously interstratified with bright red, purple, lilac, greenish, and yellowish clay-slates. The slates occasionally predominate to such an extent as to cause the rocks to assume the character of a great *clay-slate formation*, the transverse cleavage cutting across the beds generally at a high angle, and with a steady strike of west-south-west and east-north-east, but dipping sometimes to one side and sometimes to the other side of their strike."

Jukes, *Quarterly Journal of the Geological Society*, xxii. p. 332.

‡ "All the rocks of the district have been tilted into very high angles oftener above 45° than below it, and frequently even 90° or vertical. They are bent and

light-brown beds; traversed, lengthwise, by undulating, unconformable, interlacing joints, which divide the rocks into small, lenticular masses,* polished and grooved without, but of fissile structure within. Other, subordinate, quartzose beds, of blueish-green hue and uneven fracture, impoverish the *lodes,* wherever they touch them. Three series of joints—common alike to the rocks and *lodes*—bear respectively, 28°—38° W. of N.—E. of S.; 25°—30° N. of E.—S. of W.; and 15°—20° S. of E.—N. of W.†

The different conditions of the two *lodes*—or, it may, perhaps, be said, of the two *branches* of the principal *(Champion) lode*—wrought in the *Mountain-mine* ‡ are—

The Main lode, bearing	25° N. of E. —S. of W.,	dipping N. 60°—72°,	and measuring 10—42 feet in width;
,, *Mountain* ,, ,,	38° W. of N. —E. of S.,	dipping E. 62°—78°	,, 20—62 feet in width.

contorted in various directions, but generally strike with the mean run of the principal features of the ground, the lines of the shores and the crests of the hills, all ranging along lines which run nearly E.N.E. & W.S.W."

JUKES & KINAHAN, *Explanations to accompany Sheets* 197 & 198 *of the Geological Survey of Ireland,* p. 13.

"The cleavage-planes are almost vertical, inclining a shade north in Cloan, and coursing east 35° north."—SMYTH, *Ibid,* p. 30.

* *Ante,* p. 13, *Fig.* 2.

† In 1838 the Magnetic declination at Killarney was about 29° 09′ W.—Ross, *Phil. Trans.,* CXXXIX. (1849) p. 208. SABINE, *Ibid, Pl. XIV.*

‡ "An extraordinarily thick course of white, hard, wild quartz, runs in a rudely east and west direction, through a rough mass of slaty and grit rocks at an elevation of between four and five hundred feet above the sea, in the townland of Cloan. For a length of above a hundred fathoms, it is fifty to sixty feet in width, but by no means attractive to the eye of a miner, except in its southern side, where a rib of three or four feet was gossany, and at a small depth yielded copper pyrites. At a great depth, the whole lode * * * became impregnated with ore, and was, in some parts, to as much as sixty feet wide, enormous cavities standing open without support, in consequence of the strength

The *Main lode*—bearing 25° N. of E.—S. of W.—is, in direction, nearly parallel to the cleavage-planes of the adjoining rocks; but whilst it underlies 60°—72° N., they are nearly vertical: a rare—though not a solitary—instance of the *lode* dipping less than the strata.* The *Mountain lode*—ranging 38° W. of N.—E. of S., and inclining 60°—78° N.—N.E.—is—as well in direction as in underlie—oblique to both.

In each case, respectively, the steepest are always the richest parts.†

But notwithstanding the two *lodes* unite in one and the same broad body of productive vein-stone near the surface; the *Mountain lode,* which courses obliquely, is, on the whole, more highly inclined than the *Main lode,* which ranges somewhat transversely to the meridian.‡

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of the grit rock which forms the wall. At from thirty to fifty fathoms deep the lode is from twelve to fifteen feet wide, and consists of quartz, with disseminated copper pyrites. Here only a few 'arches' of ground have been left, and the inclination is one foot in six to the north.

"At the 150 fathom level the ground is worked away for a great width and height, rendered the more imposing by a branch which strikes off northward from the vein at about thirty fathoms east of the whim-shaft. This was worked, in places, to a width of twenty-six feet, and was very rich in ore, particularly on the hanging side. The chief point of note about the lode here was, however, that from its hardness and the moderate admixture of ore, it would have been, if small unprofitable, whilst from its great size, allowing of operation on a large scale, it proved highly remunerative. At the 162, a cross-cut * * * leads to a large lode of similar character, where it appeared that the shoots of ore have a tendency to incline eastward."

Smyth, *Explanations to accompany Sheets* 197 *&* 198 *of the Geological Survey of Ireland*, pp. 30—1.

* *Ante*, p. 564.

† Thomas, *Survey of the Mining District between Chasewater and Camborne*, p. 20. Henwood, *Edin. New Phil. Journal*, XXII. p. 158; *Cornwall Geol. Trans.*, V. pp. 231, 248. Fox, *Reports of the Royal Cornwall Polytechnic Society*, IV. p. 87.

‡ Fox, *Reports of the Royal Cornwall Polytechnic Society*, IV. p. 84. Henwood,

Moreover, the *Main lode* is, on an average, much narrower than the *Mountain lode*.*

The prevalence of such conditions in America, France, Ireland, and England cannot be without significance.

Of both *lodes* the chief ingredient is massive, hard, white quartz, which miners, generally,—and Cornishmen, especially,—would pronounce *unkindly;* save that near the surface it is much tinged with the salts of copper, and, at rather greater depths, with earthy brown iron-ore. Small quantities of (?) chloritic or talcose matter occur in all parts, but notably at the joints; calcareous-spar is, here and there, imbedded in the other constituents; and—from certain portions of the *Mountain lode* particularly,—the carbonate of iron is obtained, though in smaller proportions. This matrix envelopes numberless angular masses of slate; which vary, from a fraction of an inch to several feet, and even fathoms, in length, depth, and thickness. Of these many—peculiarly amongst the small and middle-sized—specimens obey no yet recognized law; † but in the larger bodies *(Horses)* the planes of cleavage are oblique to the dip of both *lodes*,‡ as well as to the

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Cornwall Geol. Trans., v. pp. 247,—50,—77,—9, *Tables CIII., CVI.; Ante*, pp. 310, 406, 527,—32, *Table XX.* Whitney, *Metallic Wealth of the United States*, pp. 260,—87.

* Henwood, *Cornwall Geol. Trans.*, v. pp. 240,—75, *Tables CI. CIV.; Ante*, pp. 410, 527,—32, *Table XX.*

† Henwood, *Cornwall Geol. Trans.* v., p. 211.; *Ante*, pp. 20,—3, 190,—4, 250,—1,—9, 312,—17,—81, 424.

‡ *Ante*, p. 604

strike of the *Mountain lode*,* yet they are parallel alike to the strike of the *Main lode** and to the dip and strike of the schistose structure in the neighbouring *(Country)* rocks,† with which, however, they are in nowise connected.

Large rich bodies of copper-pyrites occur at intervals; and at short, but unequal, distances between them, the quartzose and chloritic vein-stones are charged—more or less heavily—with smaller masses, *branches*, and grains of the same ore; which is, in fact, the only one prevalent in the district. A calcareo-siliceous matrix is rarely a productive one; nevertheless it sometimes contains small quantities of copper-pyrites and of vitreous copper. If many joints traverse the *lodes*, they are seldom rich; ‡ but where a brecciated structure is maintained, they are always poor.§

At the articulation of the two *lodes* the *Main lode* preserves its normal direction, whilst the *Mountain lode* diverges from it at an angle of some 77°, and—intersecting the schistose north (upper side-) *wall*—assumes thenceforth a greater width and a steeper slope; but, from the surface to about one hundred and

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* *Ante*, p. 604.

† Henwood, *Cornwall Geol. Trans.*, v. p. 211; *Ante*, pp. 20,—3, 190,—4, 250,—1,—9, 312,—17,—81, 424.

‡ "Those parts of the *lodes* which are traversed by longitudinal and cross joints, as well as those portions which exhibit traces of horizontal bedding, are generally unproductive."

Henwood, *Cornwall Geol. Trans.*, v. p. 232 (Abridged).

§ "Cavities lined with crystals, and imbedded masses of slate, are unequivocal signs of poverty, wherever they may occur."—*Ibid*, p. 230. *Ante*, p. 84.

forty fathoms deep, it comports itself as a *branch* of the *lode* from which it had parted. At greater depths, on the contrary, the north *wall* of the *Main lode* is continuous; a band of lilac or pale-buff coloured slate, some three or four fathoms thick, and corresponding in cleavage with the neighbouring rocks, interposing between the southern bluff extremity or *but-end* of the *Mountain lode* and the northern side of the *Main lode;* the identical band or *wall* of rock intersected by the *lode* in one spot, thus itself intersecting the selfsame *lode* in another.* Between the immediately opposite portions of the *lodes*, however, thin layers of quartz, slightly sprinkled with copper-pyrites, conformably interlie the slate. The *lodes,*—whether united or divided—consist of similar vein-stones and yield the same ore; but, when separate, they are rich at different depths.

The *Main lode* continues productive to a depth of one hundred and forty fathoms; as long, in fact, as it is connected with the *Mountain lode*, but no longer; for its riches decline when that connexion is interrupted by the band of quartzose slate, already mentioned. The body or *shoot* of copper-ore dips endlong,—as the *Mountain lode* and the *Cross-course* † also dip,—towards the east.

The *Mountain lode* is, on the other hand, generally poor during its contact with the *Main lode;* but where

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* Henwood, *Cornwall Geol. Trans.*, v. p. 326, *Tables XIV., XLIII, LII.* *Ante*, p. 192.

† *Postea*, p. 608.

they are separated, by the orey band of quartzose slate, —and the deeper parts of the *Main lode* become gradually impoverished,—opposite portions of the *Mountain lode* are proportionally enriched. Here, however, the *shoot* or body of ore—conforming in some measure to the dip of the adjoining slates and to the underlie of the *Main lode*,—declines towards the north.

The *Mountain lode*—whether it be an independent vein* or merely a subordinate *branch*—does not extend southward of the *Main lode*.

The *Cross-course* bears N.E.—S.W.; dips S.E. 76° —84°; averages about four feet in width; and consists, generally, of slaty-clay; except where it intersects the *Main lode*, and there quartz becomes the principal ingredient.

It simply severs—without *(heaving)* displacing— the *lode*.

In 1849 the Mine was	140 fms. deep;
but in 1867	252 „ „ :
in twenty-six years, therefore, it had been deepened	112 fathoms.

But though wrought, to such a depth, in rocks of schistose structure,† within a mile of the sea, the water ‡

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* "I believe the *Mountain lode* to be a distinct one, and not a *branch* of the *Main*, east and west *lode*."

CAPTAIN HENRY PASCOE, Manager of the *Bearhaven Mines*, MSS.

† "Results obtained from mines in all the metalliferous districts of Cornwall, except that of Callington * * * agree in showing the quantity of water yielded by the mines in slate is about four times as much as by those in granite."

HENWOOD, *Cornwall Geol. Trans.*, v. p. 442.

‡ "The water is not abundant, and is raised by a draft-engine, placed on the

		cubic feet		
drawn from the bottom	was only	from 2·86 to 3·27	per minute,	during summer,
„	„	about .... 3·68	„	, in winter;
discharged at the *adit*	„	from 4·83 to 5·53	„	, during summer,
„	„	some .... 6·22	„	, in winter.

For some years before the writer's first visit to Bearhaven (in 1841), all ore and rubbish had been raised in waggons, drawn through a highly inclined shaft, on iron rails, by a small high-pressure steam-engine, placed—some twenty-eight fathoms from the surface—at the *adit.**

A *Man-engine,*†—the only one yet set up in Ireland,

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top of the rocky brow."—SMYTH, *Explanations to accompany Sheets* 197 *&* 198 *of the Geological Survey of Ireland*, p. 31.

* "The Mountain mine is entered by an adit level cross-cut from the south side, leading to a whim-engine placed underground, the smoke of which ascends through the *leeries* or excavations between the walls of the vein."—*Ibid*, p. 30.

"In the *Tamar* lead-mine, Beer-ferris, Devon, a twenty horse-power steam-engine was erected at the 145 fathom level, or 290 yards below the pit's mouth, which answered the purpose intended, viz. to pump water and raise the ore. The smoke from the engine was conveyed along a flue running through old workings to the surface."—PEPPER, *Playbook of Metals*, p. 242.

Leifchild, *Encyclopædia Britannica* (Eighth Edit. 1858), XV. pp. 225—6. Moissenet, *Annales des Mines*, 6me Série, II. pp. 155, 272; *Mining and Smelting Magazine*, III. pp. 225,—72, 350; IV. pp. 12, 88, 161, 327. Thomas, Richards, Vivian, Daw, Cady, and Cock, *Epitome of Evidence, collected by Royal Commissioners on Mines*, pp. 29—33. Twite, *Ibid*, Appendix B, p. 316.

† Loam, *Reports of the Royal Cornwall Polytechnic Society*, II, p. 35. Phillips, *Ibid*, p. 43; IV. p. 57. Jones, *Ibid*, VI. p. 63. Basset, *Ibid*, VIII. p. 59. Henwood, *Report on the Employment of Children in the Mines of Cornwall* (1841), pp. 739, 813,—21,—4. Gordon, *Reports of the Royal Cornwall Polytechnic Society*, IX. Part II. p. 6. Lemon and others, *Ibid*, Part II. p. 12. Taylor, *Ibid*, X. p. 65. Lemon, Francis, Richards, and Jennings, *Ibid*, XI. pp. 15—27. Francis, *Ibid*, XIII. p. 22. Puckey, *Ibid*, XIX. p. 38. Moissenet, *Annales des Mines*, 5me Série, XV. p. 1. *Mining and Smelting Magazine*, I. p. 366. Leifchild, *Cornwall, its Mines and Miners*, p. 155. *Epitome of Evidence collected by Royal Commissioners on Mines*, pp. 24—33. Twite, *Ibid*, Appendix B, pp. 296—7. *Ante*, p. 114.

—has, since 1862, taken the miners to, and from, a depth of one hundred and twenty-eight fathoms.

Forges for the repair of tools have—as the mine has been gradually deepened—been erected, in succession, at 43, 93, 115, and 226 fathoms from the surface; the smoke from them causing little or no inconvenience, as—like that from the underground steam-engine—it passes off through different exhausted works and unused shafts, as the wind blows in one or other direction.*

The miners take underground, daily, the potatoes which form the greater part of their food; setting them on to boil, in mine-water, at the forges, and proceeding to their work; returning, however,—during the dispersion of the smoke and foul-air from blasting,—to secure a warm, if a frugal, meal.

The *Caminches lode* was wrought, in the immediate neighbourhood, for several years, with great success; but, for some time, the works have been abandoned. At *Killogue*, about a mile distant, however, extensive operations are still in progress on the same *lode*.†

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* Some thirty years ago forges were established, under similar circumstances, at great depths in *Wheal Vor* by the late Captain Mark Read; who had previously assisted his brother in superintending the *Bearhaven* mines.

† "The Allihies 'Old lode' was worked to the depth of fifty or sixty fathoms, and outward for some little distance under the sea. It has now been abandoned for a quarter of a century. * * *

"The Caminches lode, which courses N.N.W., with an inclination to the S.E.,

The metalliferous district E.N.E. of Kenmare in Kerry is about five or six miles in length; but it nowhere exceeds a mile in breadth, and many parts of it are much narrower. It is bounded on the N., E., and S. by the "upper purple series of the Old Red sandstone," which is succeeded by slates and shales, and these are overlaid by Carboniferous limestone.*

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has been proved over a length of one and a quarter miles. At its northern end, in Cloan, it formed a very productive mine, for about ninety-five fathoms long, and was worked to the depth of 162 fathoms, when it became so poor and small, that it was reported by some to 'cut out' altogether. Ten fathoms more were sunk upon it, but without improvement. * * * The lode varies from one to twelve feet in width, averaging four to six feet. Its only ore is copper pyrites, interspersed through quartz, often hard, though certain portions of the matrix are argillaceous or 'flucany.' * * *

"Further south again, in Kealogue, a very rich mine has been worked, although the regularity of the lode has been much disturbed by a succession of cross-courses, which fall in with it very obliquely. No lode at all had been found for 100 fathoms between two of these, notwithstanding numerous drivings carried on to search for it. A very exceptional feature is a sharp turn of the lode, almost at right angles to its former course close to one of these cross-courses.

This latter mine, worked to 100 fathoms deep, proves the lode tolerably good as far as the river on the south; but the vein there dwindles to a mere slide, and continues to exhibit the same unpromissing character to the furthest shaft south on the adit level."

Smyth, *Explanations to accompany Sheets* 197 *&* 198 *of the Geological Survey of Ireland*, pp. 30—1.

* "The valley of Kenmare extends eastward from the town of Kenmare to the village of Kilgarvan, a distance of about eight miles, and varies in breadth from half a mile to one mile. It is formed of a synclinal fold of lower Carboniferous limestone, the fold or bending of the strata having passed the vertical, forming a case of inversion of the strata. * * * In consequence of this inversion, the arenaceous, red micaceous, and calcareous slates to the south of the Roughty, appear to overlie the limestone of the valley."

Haughton, *Journal of the Geol. Society of Dublin*, vi. p. 208.

"The upper part of the bay, as well as the valley of Kenmare, is surrounded by the upper purple series of the Old Red sandstone. * * * A good section may be seen on the banks of the Finnihy River, * * * the dip of all the beds appears to be southwards, with an average inclination of fully 75°. * * * On the north side of the Kenmare Valley the rocks exposed are merely repetitions of purple grits and slates, which, as they are crossed, terminate in the beds

In the Caher brook, a mile N.W. of Clontoo, the Old-red sandstone is represented by arenaceous slate of argillaceo-siliceous character and brick-red hue.*

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recognised as Yellow Sandstone, which immediately underlie the carboniferous rocks of the district.

"Along the southern shore of Kenmare Bay, and in the river courses on the south side of the valley, the rocks are in every respect the same as those on the north. * * * The stream which runs into the bay to the W. of Mucksnaw Wood, exposing purple and reddish grits and slates, all dipping northwards at an average angle of 70°. * * * The most continuous section on the south side of the valley is that which commences E. of Rice Mount, and may be traced northerly to the Roughty River. All the beds appear to dip northwards at 70°.

"In the Kenmare valley the Carboniferous limestone is found to be inclined at high angles, and to be often greatly contorted, and sometimes apparently inverted. * * * At one spot N. of Kenmare, and S.W. of the workhouse, the limestone certainly dips S.S.E. at 60°; at Killowen it dips in the same direction at 70° and 80°; but at three places to the southard of that, on the banks of the river near the White house, it appears to dip to the N.N.W., at 80° or 85°. * * * The limestone is well seen also along its northern boundary, north of Cleady * * * and dipping S.S.E. at 80° to 85°. Similar limestone shows itself here and there down to Cleady bridge, up to Shanagarry lead mine and all across the valley, down to the bank of the river, everywhere dipping to the S.S.E. at angles of 50° or 60°, over a space of about 1,000 yards in width, and to within fifty yards of the line along which the red rocks rise up to the surface, either vertical or with a dip of 85° to the N.N.W. North of this tract in the river Cleady these same Old Red beds may be seen dipping S.S.E. at 85°. It would, therefore, at first sight, appear that there must be here a deep trough or wedge of limestone descending to a vast depth into the ground, having sides sloping downwards towards each other at an angle of only 5° from the perpendicular, and a base at the surface of 1,000 yards in width, with either an inversion along its southern margin, or a great fault having an upcast to the S."

Jukes, Du Noyer, & Willson, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, pp. 20,—1,—3,—4. (Abridged.)

* "To the north * * * the beds nearest to the limestone, and unconformable to it, are soft yellowish slates, with quartose veins containing micaceous iron in abundance, and under these lie the red slaty beds, denominated 'red killas' by the Cornish miner. * * * The inverted beds south of the limestone consist near the junction of a series of micaceous coarse thickly-bedded sandstones, dark-coloured and slaty beds, and calcareous slates containing nodules of clay ironstone and iron pyrites."

Haughton, *Journal of the Geol. Soc. of Dublin*, VI. p. 210.

"The yellow sandstone * * * at either side of the valley of Kenmare as far as Ardtully, is represented by a slice taken off the Old Red sandstone, and its

The slates which,—in the same neighbourhood,—separate this equivalent of the Old Red sandstone from the Carboniferous limestones, are of reddish-purple, greenish-grey, or leaden, hue; are interlaid with yellowish-green laminæ in some spots, with coal-black scales in other, and flecked with mica everywhere. They are mostly fissile; and, at intervals, their planes are scored with glossy striæ.*

The limestone is crystalline, slaty, and variously tinted with grey. It includes many short, narrow, conformable beds of calcareous spar; and, in some parts at least, crinoidal remains are not uncommon.†

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presence referred rather than proved by any exposures.

Du Noyer, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, p. 22.

* "Beneath Roughty bridge are black shales containing carboniferous fossils. These beds are so much twisted as to dip N.E. * * * and immediately east they dip underneath gray limestone, all crowded with fossils [*Orthis filiaria*, *Strophomena crenistria*, *Spirifera disjuncta*, *Athyris planosulcata*, *Fenestrella plebia*, and stems of *Actinocrinus*] as at Killarney."—Jukes & Willson, *Ibid*, pp. 22,—3.

† "The limestone of this district is uniform in character, highly crystalline, and with a slaty structure, exhibiting frequently planes of bedding and cleavage. * * * The average strike of the limestone and other beds is very constant, lying always between the limits E. 27° N. & E. 12° N. At the southern junction of the limestone and slaty beds, * * * both rocks are divided by two sets of planes: one, the true bedding, dip 70° S., and the other, of cleavage, dip 73° N. to 90°, both classes of planes being intersected by joint planes, making a solid angle of 90° with the cleavage planes. An average specimen of the calcareo argillaceous slate accompanying veins of copper ore at Green lane, afforded

Argillum	49·25
Peroxide of iron and alumina	2·03
Carbonate of lime	38·74
Carbonate of magnesia..........	7·83
Water	1·26
	99·11

As well in the equivalents of the Old Red sandstone, as in the Carboniferous slates and limestones, the planes of cleavage bear 5°—15° S. of E.—N. of W., and dip at high angles towards the S. Joints of two series range 25°—30° W. of N.—E. of S., and 15°—20° E. of N.—W. of S., respectively.

Copper and several of its ores * are less or more abundant in the Old Red sandstone series, as well as

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"Notwithstanding a careful search, several times repeated, I was unable to procure the slightest trace of fossils in the limestone of this district."

Haughton, *Journal of the Geol. Soc. of Dublin*, vi. pp. 208,—9,—10.

"The rock appears at the surface in Kenmare itself, and on each side of it. * * * It is here mostly of a pale gray, flaky or splintery limestone, in thick beds, traversed by two sets of joints at right angles to each other. It is often very difficult to determine which planes are those of stratification, and which are joints, and the obscurity is increased by the whole mass being traversed by cleavage planes, running about E.N.E. & W.S.W., and dipping southerly at 80°. It is this cleavage which gives to the limestone its flaky character, and causes it to split into thin plates of pure crystalline carbonate of lime, often coated by films of argillaceous or chloritic matter. North of Cleady the pale and dark gray limestone [is] generally flaky, and often crinoidal. * * * In following up the bottom of the valley from Cleady to Ardtully, limestone with the same general character, and in the same apparent position as that near Cleady, may be observed both north and south of the road past Caher and Cloontoo."—Jukes & Willson, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, pp. 23,—4.

* "The mineral lodes which occur in this district are lodes of copper and lead, the copper being developed at * * * the junction of the lower carboniferous limestone with the underlying red slates and sandstones, * * * the plane of the lode coinciding *nearly* with the bedding of the slate rock. * * * It is worthy of remark * * * that these lodes occur in the same geological position as the Bearhaven mine, county of Cork, which may, in fact, be considered as occurring in part of the same valley, and in the red slates south of and older than the Carboniferous limestone of the Kenmare valley."

Haughton, *Journal of the Geol. Society of Dublin*, vi. pp. 211—14. (Abridged.)

"Both lead and copper ores are found in the limestones, as well as in the Old Red sandstone rocks of the Kenmare Valley, appearing at various localities, from the town of Kenmare on the W., to Cloontoo House, close to Ardtully, on the E., a distance of about four miles. One deposit * * * said to contain purple and gray copper ores, strikes with the beds of the Old Red sandstone,

in the Carboniferous slates and limestones; but, hitherto, lead ore * has been obtained in the limestone only.

The arenaceons slate, which represents a portion of the Old Red sandstone, is interlaid, near the Caher rivulet,† by a conformable bed of quartz and quartzose slate, mixed with earthy brown iron-ore, and lightly charged with copper pyrites; but it is of inconsiderable extent.

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at Greenlane * * * S. of the basal boundary of the Carboniferous shales. Copper pyrites appears in the pale green and purple grits and slates, which occur at Cromwell's Fort, * * * and at a point on the eastern extremity of Mucksna Wood, gray copper ore is found; in both instances the ore occurs as a bed in the Old Red sandstone, and not as an ordinary lode. Trials for copper have been made in the dark purple slates and grits of the Old Red sandstone * * * N.W. of Caher.

"The Ardtully Copper Mine is worked on a true lode which strikes * * * across the limestones * * * [but it] becomes poor as it is traced to the W., where it has been found to pass out of the limestone, and cut across the Yellow sandstone beds. * * * The limestones which appear at the surface [near] Roughty Lodge contain layers of the green carbonate of copper deposited regularly between the beds. * * * In the grounds of Cloontoo * * * purple copper ore appears in the limestones, apparently following the bedding."

Du Noyer & Willson, *Explanations to accompany Sheet* 184 *of the Geol. Survey of Ireland*, p. 37. (Abridged.)

* "The lead lodes are confined exclusively to the limestone, throughout which they are developed in several parallel bands, principally, however, near the northern boundary. The lead lodes are, like the copper, *nearly* conformable to the bedding of the limestone, both in strike and dip; [but] this conformability is not complete."—Haughton, *Journal of the Geol. Society of Dublin*, vi. pp. 211—14. (Abridged.)

"Lead ore occurs in the gray limestones, close to and north of the R. C. Chapel of Kenmare; but whether as a deposited bed or in a true lode does not appear. * * *

"The Shanagarry Lode * * * appearing like a bed interstratified with the limestone * * * contained argentiferous galena; * * * [but] near the surface it produced considerable quantities of iron pyrites and blende. S. of Shanagarry Castle, another lode appears at the surface, having the same dip as the first, and also containing argentiferous galena and blende."

Du Noyer & Willson, *Explanations to accompany Sheet* 184 *of the Geol. Survey of Ireland*, p. 37. (Abridged.)

† *Ante*, p. 612.

About a furlong N. of Clontoo the limestone forms one side *(wall,)* and the (? carboniferous) slate the other, of ae mtalliferous deposit (known as the *North, Engine,* or *Ardtully lode)*;* which—nearly, if not exactly, coinciding with the cleavage-planes of both the adjoining rocks—bears 5°—10° S. of E.—N. of W.; † inclines—with but trifling exceptions—towards the S.; and measures from one foot and a half to more than ten feet in width. The shallower parts consist, in great measure, of argillo-calcareous clay mixed with earthy

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* "The Ardtully Lode occurs at the northern junction of the limestone and red slate. * * * It has been worked to a depth of sixty-six fathoms, and near the engine shaft has the limestone for its south wall, and the red slate for its north wall, * * * The slate in contact with the north wall is much softer than at a distance from it, probably owing to the readier percolation of water through the lode. As the lode is traced westward, it leaves the junction of the limestone and slate, and becomes less productive; and it has been found most metalliferous in that portion of it which lies between the limestone and slate. The width of this lode varies from three to ten feet, and is conformable to the strata; it consists of a series of smooth polished sheets or secondary walls lying within the main walls. The south wall of the lode does not come into contact directly with the limestone, but is separated from it as the north wall is separated from the red slate, by a remarkable black shining slate, coated with fibrous streaks of a mineral resembling some of the hornblendes, and this black slate forms [both] walls of the lode. The direction of the lode is very nearly due E. & W.; it underlies S. for forty fathoms, about two feet in six; it then becomes vertical for sixteen fathoms, and ultimately acquires a small underlay to the north."

Haughton, *Journal of the Geol. Society of Dublin*, VI. p. 213. (Abridged.)

[The lode worked in the Ardtully Copper mine] "strikes in a N.N.W. direction across the limestones, which dip about S. 10°, E. at 80°, the lode itself inclining to the S. [It has been described] as gray copper ore, and also purple and copper pyrites, worked to the depth of sixty fathoms. The lode becomes poor as it is traced to the W., where it has been found to pass out of the limestone, and to cut across the Yellow sandstone beds. This lode underlies S. two feet in six for the first forty fathoms, and then becomes vertical."

Du Noyer & Willson, *Explanations to accompany Sheet* 184 *of the Geol. Survey of Ireland*, p. 37. (Abridged.)

In 1838 the Magnetic declination at Killarney was 28° 05′ West. Ross, *Phil. Trans.*, CXXXIX. p. 208. Sabine, *Ibid, Pl. XIV.* *Ante*, p. 603.

brown iron-ore; enclosing, towards the N. side, small angular masses of slate thinly encrusted with copper pyrites, and slightly sprinkled as well with nodular concretions of hematite iron-ore, as with grains of native copper, vitreous copper, purple copper-ore, and copper-pyrites, throughout. At greater depths, and toward the (N.) *foot wall*, the slaty matter—which, itself, is a principal ingredient—presents but faint traces of cleavage; yet, here and there, it graduates into the schistose rocks of the underlying *Country;* some portions, however, are highly siliceous, and bodies of both massive and granular quartz are imbedded in it at intervals. Near the middle of the deposit a change of character becomes perceptible; and thence, towards the (S.) *hanging-wall*, it—like the incumbent rock—is made up of thin, ill-defined beds in which greyish limestone sometimes alternates, but is more frequently mingled, with calcareous-spar.* The ores of copper, which occur near opposite sides of the formation, differ in appearance as much as their respective vein-stones; the argillo-siliceous constituents, towards the *foot-wall* yielding yellow ore in abundance, but the grey * and purple ores in much smaller pro-

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* *Table XXI.*, columns 5, 6, 7.

† "Analysis of Gray Copper Ore from Ardtully Mine;

Silica	5·29	per cent.,
Sulphur	25·32	,, ,
Arsenic	16·07	,, ,
Antimony	3·70	,, ,
Copper	40·26	,, ,
Iron	4·54	,, ,
Zinc	3·18	,, ,
Silver	0·15	,, ,
Sulphuret of Mercury (?)	0·56	,, ,
	99·07	,, ."

HAUGHTON, *Journal of the Geol. Soc. of Dublin*, VI. p. 212.

portions; whilst the calcareous ingredients afford great quantities of the grey and purple, but little of the yellow, ore.*

The *South* or "*Forge lode*" †—situate about one hundred fathoms within the N. boundary of the limestone, and successfully wrought to a depth of twenty fathoms on the same meridian as a productive portion of the "*Ardtully lode,*" ‡—also bears 5°—10° N. of E.—S. of W., and dips 58°—80° S. Its opposite sides are bounded—and in certain parts of its range it is divided lengthwise—by undulating joints, in some places as much as four feet, but in others no more than three inches, apart. The included vein-stone—resembling the contiguous *(Country)* rock—consists

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* "At *Botallack* one of the *lodes* passes no less than three different times from granite into slate; and at every change it yields tin-ore only in the granite, and vitreous copper-ore alone in the slate. * * *

"On a general view of the [mines in Cornwall and Devon] it will appear that the *lodes* in granite, *elvan*, and the massive varieties of the slate series, have yielded beyond comparison the largest quantities of tin-ore, and of the vitreous and earthy black ores of copper, * * * whilst the *lodes* which traverse the schistose slates have chiefly afforded copper pyrites."

Henwood, *Cornwall Geol. Trans.*, v. pp. 194—5.

† "At a distance of 108 fathoms, south of the Ardtully lode, there occurs another lode of copper, which * * * lies altogether in the limestone, and so far as it has been worked, contains exclusively *horseflesh* or purple copper ore; its direction is parallel, or nearly so, to that of the Ardtully lode."

Haughton, *Journal of the Geol. Society of Dublin*, vi. p. 213.

"In the grounds of Cloontoo * * * purple copper ore appears in the limestones, apparently following their bedding; this was called the Forge lode. The same copper bed * * * is reported to have been found at the distance of 150 yards W. of Caher Bridge, adjoining Cloontoo."

Du Noyer, & Willson, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, p. 37.

‡ Carne, *Cornwall Geol. Trans.*, iii. p. 78. Fox, *Cornwall Polytechnic Trans.*, p. 88. Henwood, *Cornwall Geol. Trans.*, v. pp. 87*, 215, 233; *Ante*, pp. 270, 326, 553.

mostly, of greyish limestone and calcareous-spar. But, as well in the centre as at the sides of the deposit, sometimes one, sometimes the other, ingredient prevails; in every part, however, the limestone is sprinkled and veined with spar; and this—in one instance at least—seems to have been aggregated on some foreign (? organic) body.* To a depth of twelve fathoms purple ore abounded; and the grey, yellow, and earthy black, ores of copper—although much less plentiful—occurred also in notable quantities. Thence downward, however, they all gradually declined; and at twenty fathoms from the surface the several varieties appeared only in granules and thin veins sparingly scattered through the vein-stones. The different sorts may, perhaps, have been more frequently separate than mixed; but here and there purple ore was thickly sprinkled and minutely veined either with grey or yellow, and sometimes with both. Earthy black ore occasionally invested each of the other kinds; but usually it formed small isolated masses. Great quantities of the various prevalent ores occurred in the limestone; but all have been incomparably more plentiful in the spar.

A deposit, parallel to the "*Forge lode*," was opened in the limestone some twenty fathoms further S.; but—notwithstanding the identical nature of the vein-stone—galena was the only ore it afforded.

The "*Shanagarry lode*" †—which, about one mile

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§ *Table XXI.*, column 5.

† "The Shanagarry lode lies in the limestone, at a distance of about 130

and a half W. by S. of Clontoo, has been wrought to a considerable depth—conformably interlies the contiguous limestone, bears 15°—20° N. of E.—S. of W., and dips 60°—70° S. The barren portions are barely discerned in some, but measure more than two feet in other, places; the productive part,—which is but short,—varies in width from two and a half to four feet. Whether the *lode* be large or small, poor or rich, its earthy ingredients—like those of the adjoining *(Country)* rocks—are mostly, if not altogether, greyish limestone and calcareous spar. Where the *lode* is broad and rich,—although including small angular masses of limestone,—it consists chiefly of spar; when, on the contrary, it is small and poor,—notwithstanding spar is still present,—limestone prevails. Shallow

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fathoms from its northern boundary. It is being worked at two points, at Shanagarry and Cleady. The direction of this *lode* is accurately E. 22° N., and it is very nearly, but not quite, coincident with the strike of the limestone in which it occurs; the strike of the latter being E. 17° N. This lode has been worked * * * on a pipe vein,[a] to a depth of 42 fathoms; it underlies for 30

[a] "The pipe, in general, does not cut the Strata like the rake vein, but is an opening between them, so that if the lay or position of the Strata is nearly horizontal, so is the bearing of the pipe; but if the declination of the Strata is precipitous, the pipe shoots down headlong, almost like a shaft. Some pipes are very wide and high, others are very low and narrow. * * * The hard pipe veins contain all the variety of mineral matter, which is commonly found in hard rake veins. Some of them are found quite full of solid ore, others are full of ore mixed with spar, rider, &c.; and some are full of spar, or rider, without any ore at all. Soft pipe veins are as frequently met with as the hard; that is, such as contain soft mineral soils within the tubulous concavity of the pipe. * * * Pipe veins do not always approach the tubular form; many of them are much wider than they are high; * * *.

"All pipe veins do not continue betwixt two distinct beds of stone. Sometimes they burst their way up through the Strata, and then they have a much greater slope than the ordinary declivity of the strata, * * * and may be said to have no bearing at all, as the one end dips down towards the centre, and the other end points up towards the surface; and such of them as do not stand so near the perpendicular, seldom or never run in a straight line, but wind downward in a sloping and oblique direction. * * *.

"From some *accumulated pipe veins*, a great, and from others a less, number of nearly perpendicular fissures or rake veins meet, and join in one common centre."

FORSTER, *Section of the Strata from Newcastle-upon-Tyne, to Cross Fell in Cumberland*, pp. 246—9,—56

parts of the spar, for a few fathoms in length, are rich in galena; and smaller, yet considerable, quantities of blende and iron pyrites besprinkle as well the lead-ore as the vein-stone. Even where limestone abounds, minute proportions of similar ores are unequally scattered through the lode. At about twenty-five fathoms from the surface, however, both the pyrites and the blende disappear; and at thirty-eight fathoms galena occurs in short threads and isolated particles only.

This is, perhaps, the only part of the United Kingdom in which the ores of copper are so exclusively confined to some,* and those of lead to other,† nearly parallel deposits within so small an area.

Other metalliferous formations have been wrought in the neighbourhood,‡ but the writer has had no opportunity of examining them.

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fathoms about 2 feet in 6, when it becomes more perpendicular, and the rock also is softer. The average dip of the lode is 70° S., and of the limestone 75° S. The metalliferous part of the lode lies in sheets between thin partings of limestone and dips with them, but seems at intervals * * * to cut through the limestone sheets to the south, reappearing in other beds farther south. Near the surface this lode produced considerable quantities of iron pyrites and blende, but in the bottom levels, the argentiferous lead ore is free from these substances."

HAUGHTON, *Journal of the Geol. Society of Dublin*, VI. p. 213.

"The Shanagarry lode strikes E.N.E. * * * appearing like a bed, interstratified with the limestone, which here dips S.S.E., at 75°. This so-called lode contained argentiferous galena, and was worked to the depth of about forty fathoms. Near the surface [it] produced considerable quantities of iron pyrites and blende."

DU NOYER & WILLSON, *Explanations to accompany Sheet* 184 *of the Geol. Survey of Ireland*, p. 37. (Abridged.)

* *Ante*, pp. 616, 618.

† *Ante*, p. 619.

‡ Haughton, *Journal of the Geol. Society of Dublin*, VI. pp. 206—14. Du Noyer & Willson, *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, pp. 37—8.

The only *Cross-vein* yet known in the district bears 15°—20° W. of N.—E. of S., dips 78°—84° W., and measures from six inches to one foot and a half in width. It intersects, as well the limestone and the slate beneath it, as the *Ardtully lode* which interlies them, but causes no *(heave)* displacement of either.*

The drift is exposed in many localities; † but it contains neither metal nor ore.

At *Brownstown*, near Navan, in Meath, the rock—an upper portion of the Carboniferous-limestone ‡—is

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* "A cross course of calcareous spar intersects the Ardtully lode, underlying west, and with a direction N. 17° W. This cross course does not appear to heave the lode, which, however, becomes poor to the eastward of the cross course, and particularly *rich* at the intersection westward."

Haughton, *Journal of the Geol. Soc. of Dublin*, vi. p. 212.

† "Just inside the limestone boundary, occurs the curious green grit boulder, called Carrig-a-cappeen; it is a greenish quartzite, resting upon a pinnacle of limestone, and has the appearance of a large fungus, of which the limestone pinnacle is the stem. The whole valley near Kenmare is full of these travelled boulders, many of which, particularly the red sandstones, are grooved and striated, as if they had been held whilst being pushed along a sharp surface, which has cut and polished them."

Haughton, *Journal of the Geol Soc. of Dublin*, vi. pp. 210—11.

Du Noyer *Explanations to accompany Sheet* 184 *of the Geological Survey of Ireland*, p. 36.

‡ "In this subdivision the Upper Limestone is invariably evenly bedded and compact, of a dark gray colour, sometimes almost black. The beds are often separated from each other by layers of dark gray earthy or sandy shale."

Du Noyer, *Explanations to accompany Sheet* 101 *of the Geol. Survey of Ireland*, p. 8.

"The lowest portion of the Coal Measures in this district can with difficulty be distinguished from the top of the Upper Limestone, the chief characteristic differences being a change from limestone to a very compact dark gray calcareous grit, with layers of impure siliceous, or, often earthy so-called limestones, or highly calcareous grits."—*Ibid.*

"The beds here called Coal Measures are, most probably, the representatives of the Upper Limestone shale of Derbyshire, and the bottom part of the Millstone Grit."—Jukes, *Ibid*, p. 9.

crystalline, of blackish-blue or bluish-grey hue, disposed in thick beds; which bear nearly N.E.—S.W., dip N.W. 15°—20°, and alternate with thin layers of calcareo-siliceous shale.

The limestone adjoining the metalliferous deposit (hereafter described), rarely contains fossils; even within short distances they are scarcely common; but about one hundred fathoms W. they occur in plenty and variety.* The shales, on the contrary, are everywhere rich in organisms; amongst which the remains of plants are numerous.

Two *lode*-like bands, both bearing 18°—25° W. of N.—E. of S.,† and dipping 60°—75° E., have attracted notice; principally at *Brownstown*, yet also—though in smaller degree—at other parts of their course towards Cusackstown, about a mile S. On one of them a few shallow pits have been opened. On the other—to which the following remarks refer—a shaft has been

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* For "the following list of fossils, obtained from the Carboniferous limestone at Brownstown, by Mr. Mc. Henry of the Geological Survey," the writer is indebted to the kindness of William Hellier Baily, Esq., F.L.S., F.G.S., Palæontologist to H.M. Geological Survey of Ireland.

Corals

Zaphrentis cylindrica, *Lithostrotion junceum*, *L. affinis.*

Echinodermata.

Poteriocrinus crassus (fragments of stems).

Crustacea.

Phillipsia pustulata (tail).

Mollusca—Brachiopoda.

Orthis, *O. resupinata* (var. *gibbosa*, very large),
Producta gigantea, *P. semireticulata*, *P. mesoloba*,
Chonetes papilionacea, *C. Hardrensis*, *Streptorhynchus crenistria*,
Spirifera pinguis.

† *Ante*, pp. 541,—75.

sunk about eighteen, and a cutting at the surface, together with a drift beyond it, have been extended nearly one hundred and twenty, fathoms.

Certain portions exhibit a veined character, from being sliced by longitudinal joints; but—as these disappear one by one—the mass gradually assumes a compact and uniform structure; at intervals, however, the joints reappear, but within short spaces they again die away. Every variety, as well of compact, as of veined, structure, is thus presented in turn. The veinstone—partaking the nature of the adjoining (*Country*) rock—consists, in great measure, of calcareous-spar; largely mixed and frequently veined, however, with granular, massive, or crystalline quartz. Angular masses of blackish, or bluish-grey, limestone,—varying from merely microscopic sizes to (*horses*) some feet in width and several fathoms in length and depth,—are imbedded indifferently in the other calcareous, or the siliceous, ingredients, and sometimes partly in either; occasionally, indeed, they constitute the larger part of the formation.* Within short distances of the surface earthy brown iron-ore is largely, but unequally, mixed with friable portions of the matrix; whether of quartz or of calcareous spar. And these are often interspersed with small masses of the green carbonate of copper and of earthy black copper ore. At greater depths, the *gangue* is, at intervals, sprinkled and veined with copper-pyrites, of which the surface is frequently

* Henwood, *Cornwall Geol Trans.*, v. pp. 211,—29; *Ante*, pp. 20,—3, 181,—90,—94, 251, 381, 424, 551,—64,—8.

invested, and the crevices and joints are mostly faced, with earthy black copper-ore; but here malachite is seldom found. In all parts of the deposit, however, the ores of copper prefer a quartzose, to a calcareous, matrix.

Both the vein-stone and the *(Country)* rock adjoining contain many *(vughs)* cavities;* but those in the former are lined with crystals, as well of quartz as of calcareous-spar, whilst all are filled with calcareo-siliceous clay, which is occasionally tinged with earthy brown iron-ore. Several of the abandoned works are encrusted with calcareous stalagmite; which, here and there, is coloured with the green carbonate of copper.

At a depth of seventeen fathoms two severed joints of a large *Encrinite*† were extracted from a quartzose

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* "One remarkable character of [the Carboniferous] limestone throughout its whole course in the North of England, and indeed through all parts of the kingdom where its mass is considerable and not much divided by interposed shales and grits, is the occurrence of subterranean caverns."

Phillips, *Geology of Yorkshire*, II. p. 167.

† "Parallel veins * * * traverse the Mendips in a direction east and west, from one end to the other, and are occasionally intersected by others from north to south. They appear to pass downwards through the whole thickness of the Carboniferous Limestone, and have been proved at Charter House to a depth of 260 feet. In general they are of Liassic age; but the mineralogical and Palæontological variety they present show that they were not formed contemporaneously. Probably they were for a long time open to the Liassic seas, and must in many instances have received their contents very gradually; a Liassic fauna not only inhabited the ocean above, but lived within the Carboniferous Limestone walls of the open fissures, and the remains of Gasteropoda and other organisms may still be seen attached.

"The mineral districts comprised in this part of the Mendips and Priddy were extensively worked during the Roman occupation. * * * Owing to their imperfect mode of working, about 12½ per cent. of lead remains, which is now being extracted.[a] In general the lead-ores of the district 'prove' near the

[a] The *slimes*, *slags*, and other refuse of ancient lead-mining and smelting operations in the Mendips and at Priddy, have been estimated at from 406,560 to 500,000 cubic yards;
and ,, valued ,, £500,000 to £600,000.

Salmon, *Mining and Smelting Magazine*, VI. p. 322.

part of the metalliferous band; and somewhat deeper a specimen of (?) *Turbinolia* * was found imbedded in a subordinate vein of massive copper-pyrites.†

Large collections of the rocks and vein-stones of these, and other, districts, had—from time to time—been carefully arranged, in the Museum of the *Royal Geological Society of Cornwall*, by the writer; but,—in order to make room for specimens of another series—they were cast out by the officers, and carted off as rubbish.

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surface; and so well and completely did the Romans appear to have exhausted the veins, that little has subsequently been worked profitably. * * * At Charter House Warren * * * I examined several of the upper galleries, and found the materials therein chiefly composed of crystalline carbonate of lime, giving place occasionally to sulphate of barytes, conglomerate, and thin bands of vertical limestone, with all the ordinary features of a mineral vein. From the end of one of the galleries, at a depth of about 90 feet, I secured some samples of what appeared to be a sandy deposit, but which, when washed, was found to be almost entirely composed of dismembered joints of Encrinites, chiefly (if not wholly) of Carboniferous-limestone age, and with occasional pebbles of hæmatite iron-ore.

"At a depth of 270 feet I * * * found a deposit of deep-blue or greenish clay about 12 feet thick, * * * in places in thin horizontal layers, * * * whilst in other spots it presented a more conglomeratic character, and contained drift-wood, pebbles, &c. * * * From this one locality there have been obtained at least 115 species of fossils below the Mendip horizon for workable minerals. A few of these in the vein above, and also in the clay at the base, are, as might be expected, derived from the Carboniferous Limestone; but these species are readily distinguished from those of Liassic age, and are not more than twenty in number; they consist chiefly of different species of Bryozoa and Corals, with three species of Brachiopoda, viz. *Terebratula hastata*, *Orthis Michelini*, and *Atrypa*.

"Although the veins are chiefly productive in their upper portions, the blue clay in which these remains are found is mineralized, and contains almost 7 per cent. of galena. The wood in it is converted into jet, and its cells filled occasionally with that mineral."

Moore, *Quarterly Journal of the Geol. Society*, xxiii. pp. 455,—91,—3.

* Phillips, *Geology of Yorkshire*, ii. p. 203, *Pl. II.*

† During the writer's residence in Brazil (1843—9) his collections were dispersed; and, unfortunately, this specimen was lost.

The Detrital Gold of Wicklow.

Towards the close of 1796 gold was accidentally discovered in the Ballinvalley *—since called the Gold-mine—brook, a tributary of the river Aughrim, which rises on the eastern slope of Croghan Kinshela and falls into the Ovoca at the Wooden-bridge. The finders kept their secret awhile; but when it oozed out, the neighbourhood became crowded with gold-seekers, and for some weeks the public had it all to themselves. At length the Government interfered, and commissioned Messrs. Weaver, Mills, and King to conduct systematic operations; which were carried on, with some little advantage, until 1798, when their works were destroyed by the rebels.† In 1801 proceedings were resumed at Ballinvalley,‡ and examinations were commenced at Croghan Moira,§ Ballycreen,§ and Ballynacapogue; § but as the reopened *stream-*

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* "The discovery of native gold in the Ballinvalley stream at Croghan Kinshela was accidental, and at first kept secret; but being divulged, almost the whole population of the neighbourhood flocked in to gather so rich an harvest, actually neglecting at the time the produce of their fields. This happened about the autumn of 1796, when several hundreds of people might be seen daily digging and searching for gold in the banks and bed of the stream. Considerable quantities were thus collected; this being, as it subsequently proved, the most productive spot; and the populace remained in undisturbed possession for nearly six weeks, when the Government took possession of the stream, and stationed a detachment of militia on its banks."

Weaver, *Geol. Trans.*, v. p. 208.

Mallett, *Journal of the Geol. Society of Dublin*, iv. p. 270. Smyth, *Records of the School of Mines*, i. p. 401.

† An Act of Parliament was passed for the management of the undertaking and Mr. Mills, Mr. King, and the Author, were appointed Directors. Regular stream-works were soon established, and up to the * * * rebellion in May 1798, when the works were destroyed, Government had been fully reimbursed its advances, the produce of the undertaking having defrayed its own expenses, and left a surplus in hand."—Weaver, *Geol. Trans.*, v. p. 208.

‡ *Ibid.*

§ "But the discovery of native gold was not confined to Croghan Kinshela.

works became less productive, and as the other localities had afforded very little gold, the operations of the Commissioners were discontinued in 1802.* For nearly forty years after, the district remained unwrought, except by a few neighbouring cottagers, who gleaned particles of gold from the refuse of the Government works † and from the beds of the streams. In 1842, however, several *tin-streamers* were brought from Cornwall by an English Company ; ‡ but, as they were hardly more successful than the native poachers had been, their services were soon dispensed with, and the peasants resumed their labours. For twelve or fifteen years afterward, the gold-region was, once more, invaded by the populace; but about 1857 the *Carysfort Mining Company* obtained a lease of the Mineral rights, which, however, they have long since surrendered.

Trials were instituted in another mountain also, named Croghan Moira, and gold was obtained there, though in very small quantity. * * * One trial was made on Ballycreen and minute particles of gold were found. * * * Another trial was made in Ballynacapogue brook, and small particles of gold were obtained."

Weaver, *Geol. Trans.*, v. p. 213.

* Mallet, *Journal of the Geol. Society of Dublin*, iv. p. 270.

† " Since the workings were abandoned by Government, a few of the peasants of the country round, have occupied themselves irregularly and at intervals, in re-washing the sand which had been carefully turned over before, and from which they still obtain some gold in small grains, but scarcely sufficient to afford them the means of subsistence."—*Ibid*, p. 270.

‡ " About six or seven years ago [1843—4], some further attempts in search of gold were made by a company organized for the purpose ; * * * these, however were also unsuccessful, and the washing is again solely carried on by a small number of the peasants."—*Ibid.*

" A little glen which intersects Ballintemple has been lately worked on a small scale with some success for several years."

Smyth, *Records of the School of Mines*, i. (1853) p. 405.

In several other parts of the district,* south of the *Sulphur-course*,† particles of gold have been found, but they have not tempted the discoverers to extend their operations.

The detrital matter, is, for the most part, shallow enough to be conveniently wrought by *open-cutting*; although in one instance, at least, its depth is so great that it has been worked, in shafts sunk to the *(shelf)* rock and by *(levels)* drifts extended along its surface, more cheaply than by the removal of the whole *over-burthen*.‡

The deposit consists, in great measure, of gravel, shingle, boulders, and angular blocks of various slates; mixed, here and there, with pebbles of granite, and smaller quantities of many other earthy substances; §

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* Weaver, *Geol. Trans.*, v. p. 213. Smyth, *Records of the School of Mines*, I. p. 405. John Hodge, Esq., MSS.

† Weaver, *Geol. Trans.*, v. p. 213—19. Haughton, *Journal of the Geol. Soc. of Dublin*, IV. pp. 479—85. Smyth, *Records of the School of Mines*, I. pp. 371—96. Mahon, *The Mines of Wicklow*, pp. 36—78. *Ante*, pp. 543—60, *Table XVIII.*

‡ "As usual with such deposits of local detritus, its variation in thickness was very great even in a limited area; and thus the treasure was in some places to be attained close to the surface, in others only beneath a great thickness of valueless material more or less difficult to pierce through and remove."

SMYTH, *Records of the School of Mines*, I. p. 403.

"In some cases it was found cheaper to sink shafts from the surface and to *drive levels* from them through the sand and gravel, than it was to work the deposit by *open-cast*."—JOHN HODGE, ESQ., of *Ballymurtagh*, MSS.

§ "The gold was * * * dispersed through a kind of stratum composed of clay, sand, gravel, and fragments of rock, and covered by soil, which sometimes attained a depth of from twenty to fifty feet in the bed and banks of the different streams. At Ballinvalley it was constantly found that the gold was attended by magnetic ironstone, sometimes in masses of half a hundred weight, by magnetic iron sand, by cubic and dodecahedral iron pyrites; and in small pieces and grains, by specular iron ore, brown and red ironstone, iron ochre, fragments of tinstone crystals, wolfram, grey oxide of manganese, pieces of quartz and

as well as with masses of several ferruginous minerals,

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chlorite, and sometimes fragments of quartz crystals. * * * Several of the contemporaneous quartz veins contained in the mountain * * * [yielded] magnetic iron stone, iron pyrites, copper pyrites, blende, and iron ochre, with chlorite, and quartz crystals. * * *

At Ballycreen the gold was " accompanied by magnetic ironstone, magnetic iron sand, compact brown ironstone, cubical iron pyrites, and numerous small garnets. * * * In Ballynacapogue brook particles of gold were obtained, with magnetic ironstone, magnetic iron sand, and fragments of tinstone crystals."

Weaver, *Geol. Trans.*, v. pp. 209,—10,—13 (Abridged).

" The following list comprises all the species which I have been able to detect, but probably does not by any means exhaust the number of those which actually exist in the sand from various parts of the bed of the principal stream;—gold, platina, tinstone, magnetic oxide of iron, micaceous iron, red iron ochre, hydrous peroxide of iron, common clay ironstone, iron pyrites, titaniferous iron, arsenical iron, wolfram, oxide of manganese, copper pyrites, galena, sulphuret of molybdenum, sapphire, topaz, spinelle, zircon, garnet (two varieties) quartz, prase, augite, chlorite, felspar, and mica. * * *

The occurrence of tinstone in the sand is mentioned by Weaver, but he does not seem to have been at all aware of the large quantities in which it exists. From the comparatively small portion [certainly not more than 150 lbs.] of sand which I had an opportunity of examining, I obtained about [0·0233 its weight] $3\frac{1}{2}$ lbs. of stream tin, a portion of which being reduced, yielded an ingot, which, when refined by a second fusion, is hardly inferior to the finest grain tin. * * * The mineral itself occurs in grains varying in size from fine sand up to pebbles of half an inch in diameter, and for the most part of a dark brown colour, with some fragments of various tints of yellow and red; some presenting the peculiar appearance to which the name of " wood tin " has been given. All these varieties are slightly translucent, some of them highly so. Many of them present distinct traces of their original crystalline form. * * * The specific gravity of some picked crystals was 6·753. A careful analysis of this tinstone gave as its constituents—

Peroxide of tin	95·26
Peroxide of iron	2·41
Silica	0·84
	98·51

" The remainder of the sand consists of the detritus of the adjoining rocks, which are principally clay-slate and mica-slate."

Mallet, *Journal of the Geol. Society of Dublin*, iv. pp. 270,—1,—2,—3,—6 (Abridged).

" The gold occurred, disseminated through an irregular bed composed of clay, sand, and fragments of rock more or less rounded. * * * A great number of other minerals accompanied the gold, * * * [its] most important companion is, however, * * * the tin-stone; and from having been able to detect but little

some amount of tinstone,* small fragments of sundry other ores, and gold in minute proportions; all imbedded in sand and clay, the *débris* of neighbouring rocks.

Some of the earlier *nuggets* weighed several ounces apiece; but, even then, most of the gold consisted, and now the whole consists, of scales and granules of merely a few grains each. In many of the specimens, however, metallic threads interlace a matrix of wolfram, or of brown iron-ore.† Whether the masses are, large or small, of auriferous matrix or of pure metal, mostly

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of it on the spot, I was much surprized at the announcement that Mr. Mallet had obtained 3½ lbs. of stream-tin from about 150 lbs. of the sand. * * *

"It is not without interest to observe that many of the minerals [associated with gold in Coolbawn] are identical with those exhibited in the lodes of Ballycoog and Moneyteige, * * * and, moreover, that from the form of the hills it would be very possible to derive the spread of the auriferous drift from that strongly marked ridge. Indeed, I am inclined to infer that it was the back or upper part of these lodes, the waste of which furnished the greater part of the alluvial metallic substances found in the valleys below,—and amongst them of the gold."

Smyth, *Records of the School of Mines*, I. pp. 403,—4,—5,—6 (Abridged).

Manoel da Ferreira Camara (Southey's), *Hist. of Brazil*, III. p. 827. Gardner, *Travels in Brazil*, p. 506. Murchison, de Verneuil, & von Keyserling, *Russia in Europe and the Ural Mountains*, I. p. 476. Whitney, *Metallic Wealth of the United States*, p. 140. Daubrée, *Annales des Mines*, 4me Série x. pp. 1—21. Dufrénoy, *Ibid*, 4me Série, XVI. p. 113. Ulauyaly, *Ibid*, 5me Série, III. p. 832. Selwyn, *Quarterly Journal of the Geological Society*, XIV., p. 536. Atkinson, *Ibid*, XVI. p. 241. Laur, *Annales des Mines*, 6me Série, III. p. 412. J. Arthur Phillips, *Mining and Metallurgy of Gold and Silver*, pp. 40—6, 58, 96—9, 106—7,—10,—25. *Ante*, pp. 342—8, 383—4.

* "On the borders of the granite near Cape Raja, in the province of Soengei-Liat, * * * gold is found in the sand on the sea shore. The gold is found there with tin ore, and it occurs in the same way at the top of various small valleys in the provinces of Blinjoe and Djeboes."—Van Diest, *Banka, and its Tin Stream-works* (Translated by Clement Le Neve Foster, B.A., D.Sc., F.G.S., &c.) p. 64, Note.

Ante, p. 472.

† "The native gold of Croghan Kinshela occurred in massy lumps, and in

they seem to have suffered great attrition; yet amongst them—as amongst the rich detritus (*Cascalho*) of the Gualaxo, the Doce, and the Periçicaba in Brazil *—small well-preserved crystals of gold have been, sometimes obtained.

Its quality—like that of stream-gold generally †—is very good; ‡ the entire produce of the Government

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smaller pieces; down to the minutest grain. One piece weighed twenty-two ounces, another eighteen ounces, a third nine ounces, and a fourth seven ounces. * * * I observed and collected some specimens, which shew that the gold, magnetic ironstone, and wolfram, were each of them frequently intermingled with quartz; and I have also a few specimens, which exhibit the gold not only incorporated with iron ochre, but ramifying in slight threads through wolfram. Some of the gold, though very rarely, occurred crystallized in octohedrons, and also in the elongated garnet dodecahedron. * * * The largest piece obtained at Croghan Moira [did not exceed] two and a half pennyweights in weight."

Weaver, *Geol. Trans.*, v. pp. 209,—13.

"The gold occurs in grains of all sizes from the smallest spangle up to a mass weighing nearly twenty-two ounces, the largest hitherto found. * * *

"Mixed with the gold are some very small flattened grains of a white colour and metallic lustre, which, as far as their minute size permitted me to examine them, appear to present all the characters of platina."

Mallet, *Journal of the Geol. Soc. of Dublin*, iv. p. 271.

"Many of the pepites or nuggets of gold were found in cavities amongst [the] rough, up-turned, and broken edges of the clay-slate, * * * in the bed of the brook. Higher up the valley a considerable cover of detritus overlies the solid rock, attaining in some places a thickness of 50 feet, and increases to a great extent the difficulty of working with advantage; since the precious metal was only found in a thin bed at the bottom of this mass of useless sand and soil. * * * The particles were generally minute scales, but large solid lumps were found from time to time."

Smyth, *Records of the School of Mines*, i. pp. 408.

* *Ante*, p. 356.

† Boussingault, *Annales des Mines*, 3me Série, i. p. 446. Domeyko, *Ibid*, 3me Série, v. p, 169. Forbes, *London, Edin. & Dublin Phil. Mag.* (4th Series), x. p. 22. *Ante*, p. 359.

‡ "The specific gravity of some small grains I found to be 16·342. The analysis of these grains gave—

Gold	92 32
Silver	6·17
Iron	0·78
	99 27

experiment having ranged from $21\frac{3}{8}$ to $21\frac{7}{8}$ carats * fine.

It is believed that the peasantry collected

during the six weeks of their occupancy in 1796 .. about	800·000†	ounces	of gold.
From 1796 to 1802 the Government obtained	944·198‡	,,	,, ;
& ,, 1857 ,, 1862 the *Carysfort Mining Company* extracted about............	85·000§	,,	,, .

Of the quantities procured by the *English Mining Company*, and by the poachers during their several incursions, it has been found impossible to procure account. ||

Whilst the officers of Government wrought the detrital deposits, they also attempted to find the parent

"This is equivalent (neglecting the iron) to $8\frac{1}{4}$ atoms of gold and 1 [atom] of silver."—Mallet, *Journal of the Geol. Soc. of Dublin*, iv. p. 271.

* Weaver, *Geol. Trans.*, v. p. 211.

† "The peasantry obtained about eight hundred ounces of gold during the [six weeks] they continued at work."
Mallett, *Journal of the Geol. Soc. of Dublin*, iv. p. 270.

‡ "The total quantity of native gold collected by Government [between 1796 and 1802] amounted to 944 ounces, 4 pennyweights, and fifteen grains, of which 58 oz. 16 dwts. 1 grain were sold as specimens at £4 the ounce, amounting in value to £236. 10*s*. 8*d*. The remaining 885 oz. 8 dwts. 14 grains, I melted and cast into ingots which weighted 848 oz. 18 dwts. 5 grains. Hence the loss in melting was 36 oz. 10 dwts. 9 grains, or nearly $4\frac{1}{4}$ per cent., which arose from disseminated particles of quartz. The ingots * * * were bought by the Bank of Ireland at prices varying from £4. 0*s*. 6*d*. to £4. 2*s*. 0*d*. per ounce amounting in value to £343. 17*s*. $3\frac{1}{2}$*d*. Hence the aggregate value of the native and ingot gold was £3675. 7*s*. $11\frac{1}{2}$*d*."—Weaver, *Geol. Trans.*, v. p. 211.

§ "This Company has long since ceased to search for gold in Wicklow, and has surrendered the Crown Licence. Long years and heavy cost of search produced only 85 ounces of metal."
J. S. Hoare, Esq., Secretary of the *Carysfort Mining Company*, M.S.

|| "Since the undertaking was abandoned by the Government, it has been attempted to work the same deposits by a company, but without success, partly, it may be presumed, from the rarity of the precious metal, and partly from the difficulty experienced in all gold-streaming or gold-digging regions of obtaining from the workmen the full produce of their labours. * * *

rocks and veins; but without success.* Indeed the only part of Wicklow which has yet afforded native gold *in place* is the *Sulphur-course* at *Ballymurtagh*; and, even there, the small quantity hitherto obtained has not encouraged further search.†

"Of late years, only a few of the neighbouring peasants have from time to time been engaged in gold-washing, and it is very difficult to form a fair estimate of the remuneration yielded them by their labour."

Smyth, *Records of the School of Mines.* I. 402.

* "Numerous trials were made by driving and sinking on the veins previously known, and subsequently discovered. * * * By the Ballinvalley trench alone, twenty-seven veins of quartz were found, varying from nine inches to four feet wide, in a distance of 700 fathoms; and in the same manner, by the Ballinagore trench eighteen quartz veins were discovered in a distance of 600 fathoms. * * * The mineral substances obtained, were subjected to the operations both of fire and of amalgamation; but in no instance was a particle of gold elicited from them either by the one or the other process."

Weaver, *Geol. Trans.*, v. pp. 210—12.

† John Hodge, Esq., of *Ballymurtagh*, MSS. *Ante*, pp. 549—50.

Notice of the *CLOGAU* Gold-Mine, in North Wales.

The *Clogau* gold-mine, some five or six miles W.N.W. of Dolgelly, and more than a thousand feet above the sea, is wrought in a lower part of "*the Silurian System.*" *

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* "The structure of this district is very singular, consisting of an immense number of alternate and parallel beds of igneous and sedimentary rocks, traversed by vast numbers of mineral veins, and trap dykes. * * * A complete system of auriferous veins exists throughout the Snowdonian or lower Silurian formations of North Wales."

Dean, *Reports of the British Association*, 1844, Part ii. p. 56.

"On the N. & W. of the lower part of the River Mawddach lie the lower part of the Lingula-flags and the Cambrian rocks. The latter consist of coarse, thick-bedded greenish-grey grits. * * * These are overlaid by that part of the Lower Silurian rocks known as the Lingula-flags, which here consist mostly of blue slaty beds, generally more or less arenaceous, and partly interstratified with courses of sandstone. * * * Both Cambrian and Silurian rocks have been penetrated by numerous greenstone-dykes. Many of them are of a light grey colour and highly calcareous. Others assume the colour and texture of ordinary greenstone. Some of them are magnetic. Amongst the Cambrian sandstones they run in all directions, sometimes with, but more generally across, the strike. In the Silurian region they more generally run more or less parallel with the lines of bedding."

Ramsay, *Quarterly Journal of the Geol. Society*, x. p. 242.

"The now celebrated *Clogau Gold Mine* situate * * * at an elevation of 1,000 feet above the level of the sea * * * about a mile and a half north of the 'Halfway House,' on the turnpike-road from Dolgelley to Barmouth * * * [has been opened on] a quartzose vein which traverses altered palæozoic slates near the junction of an eruptive bar of porphyritic greenstone."

Readwin, *Reports of the British Association*, 1861, Part ii. p. 130; 1862, Part ii. p. 90.

"Halfway between Dolgelly and Barmouth an impetuous stream, descending from the high range of Llawllech, pours its waters over a rocky bed to join the Mawddach below Pontddu. On either side of this * * * river there rises a mountain, in which copper veins have, for many years, been worked on the west, the Vigra, and on the right [east] the Clogau. * * * [The lode intersects] dark schistose rocks of the lower silurian formation, with which are associated both interstratified and intrusive or dyke formed greenstones. On the north, at the distance of a few hundred feet, the massive greenish grits of the Cambrian system pass out from under the highly inclined beds of the lower silurian or lingula flags."—Smyth, *Mining and Smelting Magazine*, i. p. 361.

"Originally the lodes of Vigra and Clogau were chiefly worked for copper,

The rock which accompanies the *Saint David lode*,—where, at intervals, its outcrop is exposed, at the surface, and in the S., lower, or *foot-wall*, of the upper (gallery) *level*,—consists principally of felspar and chlorite; mixed, however, with both siliceous and calcareous matter, and sprinkled with microscopic crystals of oxydulated iron.* In the opposite side *(wall)*, on the contrary,—whilst similar ingredients occur here and there—homogeneous greyish-blue slate prevails; and in the lower *level*, some twelve or thir-

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with little or no profitable result, but about 1854 the discovery of gold in the rejected rubbish of the old workings at Clogau, and also in the abandoned lode, raised a kind of gold furor in North Wales. * * * Of late years, however, since 1859, the gold vein * * * which intersects the Lingula flags about a quarter of a mile farther north than the old Clogau copper lode near the outcrop of the Cambrian grits, has been worked to a great advantage."

Ramsay, *Memoirs of the Geological Survey*, III. p. 47.

"Fragments of the great *Paradoxides* were found, at the famous gold-mines of Dolgelly, about the same time by Mr. Readwin, and by his assistant-chemist, Mr. Ez. Williamson."—Salter, *Quarterly Journal of the Geol. Soc.*, XXI. p. 477; *Memoirs of the Geological Society*, III. p. 247.

J. Arthur Phillips, *Mining and Metallurgy of Gold and Silver*, p. 16.

"The geological position of the Clogau quartz lode is in the Lower Silurian Lingula-beds, close to their junction with the Cambrian strata of the Geological Survey, on which these beds rest conformably; and in close proximity to the lode they contain the *Paradoxides Davidis* in abundance. In these strata are seen numerous intrusive masses, and, as it were, sheets of true diabases (described and coloured by the Geological Survey as greenstones) apparently at first sight contemporaneous with the beds themselves, but which, although frequently found to follow the strike of the fossiliferous beds for long distances, and even at times to coincide more or less with their dip, will nevertheless be sooner or later observed to break through both the strike and dip of these strata. * * * These diabases are composed of a felspar base in conjunction with diallage and chlorite, and frequently, owing to incipient decomposition of these silicates, effervesce slightly with acids, thus revealing the presence of a trace of carbonate of lime."

David Forbes, *London, Edin., and Dublin Phil. Mag.*, Fourth Series, XXXIV. p. 339.

* "The Lingula flags as a whole may be described as * * * formed by the repetition of very numerous very thin, slightly waved felspathic and siliceous layers, of a light bluish grey colour."

Ramsay, *Memoirs of the Geological Survey*, III. p. 20.

teen fathoms deeper the same rocks appear. Southward, however, felspathic and chloritic beds mostly of compact, but sometimes of fissile, structure, alternate with homogeneous, greyish-blue, clay-slates; the *lode* —from the obliquity of its range to theirs—intersecting them all in various parts of its course. The several planes, as well of bedding throughout the formation, as of cleavage in schistose parts of it, range from 15°—25° E. of N.—W. of S. to 30°—40° N. of E.—S. of W.; * within short distances of the *lode* they dip 70°—80° N., but where the mountain slopes towards the Mawddach—and beds of (diabase) greenstone are numerous—they have an opposite, although a lower, inclination.† Throughout the neighbourhood two series of joints prevail; one striking 35°—45° W. of N.—E. of S., the other 30°—40° N. of E.—S. of W.; beside others coursing 18°—25° S. of E.—N. of W., —8°—24° W. of N.—E. of S.,—and 14°—24° E. of N.—W. of S. respectively, but these seem of merely local occurrence.

The *lode* bears 18°—28° N. of E.—S. of W.: ‡ and —near the surface as well as at the upper *level*—

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* "In 1840 the Magnetic declination was about 26° West."
Sabine, *Phil. Trans.*, cxxxix. *Pl. XIV.*

† "The dip of the cleavage [is] towards the south-east and north-west, but more frequently the former, in accordance with the average dip of the strata."
Ramsay, *Memoirs of the Geol. Survey*, iii. p. 22.

‡ "The auriferous veins of Merionethshire traverse two other sets of veins, and have an average bearing of N.N.E. and S.S.W., and like the others, with a north dip. These veins are very numerous, and are filled with argillaceous substances, iron pyrites, and iron and blende ores. In width they vary from $\frac{1}{8}$ of an inch to 6 or 8 inches, but sometimes expand to 2 or 3 yards. In many cases they split into minute branches. Where the auriferous veins traverse

certain parts are almost perpendicular whilst others dip 75°—85° N.; in the lower *level*, however, it declines—sometimes no less than 60°—70°—towards the S. Its width—ranging from a fraction of an inch upward—is usually from three to four feet. It consists for the most part of quartz, calcareous-spar, and —as the adjoining *(Country)* rock is of one kind or other—either felspathic and chloritic matter or homogeneous dark-blue slate. The quartz and the calcareous-spar often occur separately; but occasionally a body of one may include granules, small shapeless masses, and

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[certain of] the quartz veins they are generally very productive of gold, the quartzose veins, if metalliferous, becoming enriched on the south side of the intersection. The sides of the auriferous veins, where they pass through the quartzose veins, are generally cellular, and in the cells the gold is * * * for the most part deposited. * * * Some of the gold ores produce from [0·000004 to 0·001836 their weight] 3 dwts. to 60 oz. of gold per ton."

Dean, *Reports of the British Association*, 1844, Part ii. p. 56.

" A quantity of what was called ' poor copper ore ' was raised from ' the Saint David's ' lode and sold many years since; but in 1854 this ' poor copper ore ' was examined, and indications of native gold in considerable quantities were found."—Readwin, *Ibid*, 1861, Part ii. p. 130.

" The St. David's lode * * * in which gold had been found in 1854 * * * lies about a quarter of a mile further north than the Clogau copper lode, coursing in the same manner about E.N.E. by N. * * * The vein itself, where well developed, is from $2\frac{1}{2}$ to 9 feet in width, between distinct walls, especially on the south, underlying commonly to the north, but on the whole nearly perpendicular. It is composed of quartz and calcareous spar, the latter sometimes forming a body of several feet in width; and when the calcite puts on the appearance of a finely granular and friable marble, it frequently contains gold. * * * Spots of iron and copper pyrites are not unfrequent, and hence the lode was originally opened upon for copper, fragments of the more or less talcose schist of the walls; and sometimes in one part, sometimes in another, the * * * points and spangles of gold may be seen disseminated in the calc spar or quartz, often accompanied by bright white crystalline scales of the mineral of tellurium, sulphur, and bismuth, called tetradymite. The laminæ of the rocks which form the country on either side of the lode strike a few degrees more north of east so that they are intersected somewhat obliquely by the walls. * * * Planes of division nearly horizontal cross the lode from one wall to the other. These, in some veins, we may see to be filled with zinc blende or calc spar, * * * but at Clogau

short narrow veins, of the other, and sometimes the two are intimately mingled; at intervals also the rocky ingredients are sprinkled, veined, or transfused with either separately, or with an admixture of both. Pearl-spar, the sulphate of barytes, and other earthy minerals, appear here and there, but in much smaller quantities. At and near the surface earthy brown iron-ore abounds. In rather deeper, yet in comparatively shallow, portions of the *lode*, however, iron-pyrites and yellow copper-ore are—as amongst certain auriferous deposits in Brazil,*

I have been unable to observe that the gold has any connexion with these comparatively late fissures. There are [parts of the lode] where a mere thread of spar, or even a slight division only, * * * constitutes the only vestige of what, a fathom or two back, was a body of 9 feet wide. * * * [Moreover] one portion where the gold is visible, will be exceedingly rich; another, where, perhaps, it can be no longer seen, will pay; another will not contain a trace; and further, perhaps, the lode itself is for some distance entirely nipped to nothing."

Smyth, *Mining and Smelting Magazine*, I. pp. 361—2. (Abridged.)

"The auriferous quartz lode at Clogau runs about 18° north of east and dips at a high angle (88°) to the south cutting through both the fossiliferous strata and the intruded diabases; * * *. The mining explorations carried on hitherto appear to indicate that this quartz lode is much richer in gold at the parts where it cuts through the Lower Silurian Lingula-beds, with their accompanying intrusive diabases, than in greater depth where it traverses the Cambrian grits. The accessory minerals found associated with the gold were tetradymite, iron pyrites, galena, chlorite, calcite, dolomite, ankerite (?), chalybite, and sulphate of barytes. These minerals as well as the native gold itself are distributed very irregularly in the quartz. When the quartz contains patches of calcite, dolomite, and chalybite, and includes splinters of the neighbouring clay-slate, it is regarded by the miners as more likely to yield gold than when the lode consists of quartz alone. Although the gold sometimes is found alone imbedded in the colourless quartz, it occurs more often in conjunction with more or less iron pyrites, and other above-mentioned metallic compounds, which usually occur as small patches, nests, or aggregations in the quartz. When small pieces of the bluish-grey slate are found isolated and enclosed in the quartz of the lode, it is common to find the gold and other metallic minerals adherent to or crystallized on the under faces of such fragments."

David Forbes, *London, Edin., and Dublin Phil. Mag.*, Fourth Series, XXXIV. p. 339. (Abridged.)

* *Ante*, Henwood, *Cornwall Geol. Trans.*, VI. p. 144; *London, Edin., and Dublin Phil. Mag.*, XXV. p. 342; *Ante*, pp. 194—5.

Chili,* and the United States,†—freely, though unequally, distributed; but, notwithstanding these are limited to neither of the vein-stones, they prefer a quartzose to either a sparry or a felspathic matrix. Small quantities of blende occur frequently; particles of galena are widely scattered; and—accompanied by many of the minerals which accompany tellurium‡ and various ores of Bismuth§ in the gold-fields of Minas Geraës and Virginia,—minute crystalline scales of tetradymite present themselves in distinct clusters. Both the quartzose and the sparry ingredients—whether separately aggregated, or mingled in different proportions—contain, at intervals, particles and grains of gold, and are intertwined with golden threads which unite in small *nuggets* at their reticulations; occasionally also isolated atoms of the metal are confined to certain lines, which differ in no appreciable respect from contiguous portions of the vein-stone. The gold may, perhaps, be less abundant, but—as in different parts of the calcareo-siliceous bed which underlies the *jacotinga* in *Cocaës*‖ and *Gongo Soco*¶—it is of coarser grain, in sparry, than in quartzose, sections of the deposit.** Granules and scales of gold some-

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* Domeyko, *Annales des Mines*, 4me Série, IX. pp. 368—9. Caldcleugh, *Travels in South America*, I. 351. Sampson Waters, Esq., MSS. *Ante*, pp. 167, 378.

† Ansted, *Scenery, Science, and Art*, p. 288. Henwood, *Mining Journal*, 29th January, 1853. Whitney, *Metallic Wealth of the United States*, p. 128.

‡ Henwood, *Cornwall Geol. Trans.*, VII. p. 229; *Ante*, pp. 180, 299, 336—82.

§ *Ante*, pp. 179, 336.

‖ *Ante*, p. 245,

¶ *Ante*, p. 249.

** Henwood, *Reports of the Imperial Brazilian Mining Association*, XLI. p. 8.

times adhere to, but they are seldom imbedded in, the slaty constituents. If, as seems likely, the iron and copper pyrites contain gold,* it is—as at *Morro Velho* †—masked by its matrix ; under proper treatment, however, profit is often made by the extraction of metal from a vein-stone in which the unaided eye fails to detect it.*‡

From the middle of June, 1860,§ to the end of December, 1867,|| the mine supplied

	tons (*Avoir.*)			
	9,181·6518	of ore, which yielded..	179·1512	lbs. (*Troy*) of gold,||
&	127·4308	,,	.. 929·6384	,, ,, ,||
total..	9,309·0826	,,	1,008·7896	,, ,, ;||

the first having afforded ..	112·39 ||	grains of metal per ton,	or 0·00000717	its weight of gold,
,, second ,, ..	4,202·06 ||	,, ,,	,, 0·00198461	,, ,
mean	686·06 ||	,, ,,	,, 0·00004375	,, ;
the poorest parcels ,, ..	36·00 ||	,, ,,	,, 0·00000230	,,
,, richest ,, ,,	717,600·00 ||	,, ,,	,, 0·04576530	,, .

* In 1836 specimens of copper pyrites, represented to contain gold, were shown to the writer at *Cae Mawr* near Tyn-y-croes by the late Mr. Charles O'Niel.

Ramsay, *Quarterly Journal of the Geol. Society*, x. p. 243. Readwin, *Reports of the British Association, for* 1862, Part II. p. 89.

"The pyrite of most gold regions is auriferous. The fact is not apparent in any of the external characters."—DANA, *Mineralogy*, fifth Edition, p. 63.

† Henwood, *Cornwall Geol. Trans.*, VI. p. 144. *London, Edin. & Dublin Phil. Mag.* XXV. p. 342.

‡ The Brazilians burn their worn-out *bateas*, in order to recover from the ashes the particles of gold which are always imbedded in the wood during use.

§ Readwin, *Reports of the British Association*, for 1861, Part II. p. 130; for 1862, Part II. p. 90. Smyth, *Mining and Smelting Magazine*, I. p. 364. Hunt (Phillips's), *Mining and Metallurgy of Gold and Silver*, p. 16.

|| Accounts of the Mine, obligingly supplied by Robert Gillman, Esq., Managing Director of the *Vigra* and *Clogau* Mining Company.

"The quantity of gold raised from this lode between April 1860 and May

The gold averaged twenty-two carats fine.* †

The confronting *Table (XXII.)* shows the quantities and proportions of gold obtained from the detrital deposits and vein-stones of various Countries.

1867, as officially accounted for to Her Majesty's Office of Woods and Forests, is 12,416 oz." [1,034·666 lbs. *Troy*].

MURCHISON, *Siluria,* fourth Edition, p. 450.

* *Ante,* p. 641, Note ‖.

† Two specimens of gold from this submitted to examination afforded

	I.	II.
Gold	90·16	89·83
Silver	9·26	9·24
Copper and iron	trace	trace
Quartz	0·32	0·74
Loss in analysis	0·26	0·19
	100·	100·

DAVID FORBES, *London, Edin. & Dublin Phil. Mag.,* fourth Series, XXXIV. p. 339.

On the Chromate of Iron (lately) wrought at Corri Charmaig in Perthshire.

Amongst the many metalliferous deposits laid open by the late Lord Breadalbane*—for sake of employing the working population on his vast estate,†—some have been more valuable,‡ but none are more interesting than is the chromate of iron wrought, from time

* John fifth Earl and last Marquis of Breadalbane, P.C., K.T., F.R.S., Lord Lieutenant of Argyllshire, President of the Society of Scottish Antiquaries, &c., &c., &c., who died in 1862.

† "Lord Breadalbane expended very large sums in improving the machinery and extending the subterranean works in his lead-mines of Tyndrum; and though frequently advised as to the heavy losses he was incurring, he always replied, with a noble generosity, that the works supported a large body of men and their families, and must be kept up."

Ramsay (Anniversary Address to the Geological Society in 1863), *Quarterly Journal of the Geological Society*, XIX. p. xxxv.

‡ At *Tyndrum*,—the most ancient, largely-wrought, and productive mine in Breadalbane,—a fine-grained granular quartz-rock, interlaminated with yellowish-white mica, passes into and is overlaid by pale-buff and lead-coloured mica-slate towards the S. The quartz-rock is thick-lamellar, but the slates are mostly fissile; their planes of structure bearing 15°—20° S. of E.—N. of W., and dipping 20°—70° S. The principal *lode*—maintaining a tolerable parallelism to the joints of one series—ranges 18°—25° E. of N.—W. of S.; dips 60°—85° E.—S.E.; and measures two feet in some, but at least thirty in other, places. As its direction is oblique to the line of their junction, it traverses quartz-rock in one, and mica-slate in another, part of its course; at the boundary, however, its opposite *(walls)* sides are—for short distances—of different descriptions. Its principal ingredients are granular quartz and felspathic or slaty clay enclosing angular and rough spheroidal bodies of massive quartz, beside smaller quantities of the sulphate of barytes and calcareous-spar. The granular portions—whether quartzose or sparry—are largely mixed and veined with galena, often interspersed with either blende or iron pyrites, and sometimes with both; copper pyrites occurs at intervals, but always sparingly; and—near one of the cross-courses—minute proportions of earthy cobalt and cobalt bloom have been obtained. The body, *course*, or *shoot* of ore—limited to certain portions of both the rocks, and conforming in some measure to the inclination of their structural planes, as well as to the slope of the mountain-side—dips endlong towards the S.—S.E.

Several smaller *(branches)* veins diverge from, and within short distances re-

to time, at Corri Charmaig near the head of Loch Tay.

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unite with, the principal *lode;* but—although similar in other respects—they are much less productive.

The works—carried on by means of *levels* opened at different elevations in the mountain,—measure about two hundred fathoms in vertical extent.

Of two *cross-courses,* which bear 25°—30° W. of N.—E. of S.; one, dipping 60°—70° E., averages two feet; the other, consisting of two *(branches)* veins, both dipping 68°—75° W., measures altogether about four feet in width. Whether united or divided, they are composed of granular quartz traversed by short unctuous joints in one part of their range, but of slaty clay in the other; near the *lode,* however, the former affords traces of earthy cobalt and cobalt bloom, whilst the latter is barren throughout. One *heaves* the *lode* nearly twelve, but each *branch* of the other displaces it about six, feet; every displacement, however, is *(L.—G.A.)* towards the left-hand, and to the side of the greater angle.

From 1741	to 1745	the mine afforded	... .	1,697·83	tons of lead-ore	,
„ 46	„ 60	„	....	2,046·60	„	,
„ 61	„ 62	„	....	330·22	„	,
„ 63	„ 68	„	....	942·85	„	,
„ 68	„ 91	„	....	4,195·00	„	,
				9,212·50	„	.

In 1860, however, the returns had fallen to....	80·85	„	,
& in 1861 „	62·00	„	.

each square fathom of the *lode*, wrought during 1861, having yielded 0·47 ton of ore only

The ores of cobalt, obtained from the commencement of the undertaking to the present time, scarcely amount to four tons; and as they contain less than two per cent. of metal, whilst every effort to sell them has failed,—they still remain on the mine.

R. E. Raspe[a] *(Report dated London* 10*th of December,* 1791, in the Muniment

[a] "Rudolf Erich Raspe, distinguishable henceforth as the first collector of [Baron] Munchausen's Adventures, * * * was born in Hanover in 1737, studied at Göttingen and Leipzig, and held for some time the position of librarian in his native town. He was afterwards a professor and curator of the Cabinet of Antiquities and Coins at Cassel. Between 1764 and 1765, he published several scientific treatises in Latin, German, and English, and a poem called *Hermin and Gunilde.* * * * He also reviewed *Ossian's Poems* and *Percy's Reliques,* with translations from each. His career at Cassel ended [unfortunately]; but having made his escape, he, at length, settled in England. In this Country, although his name was erased from the list of the Royal Society, of which he had previously been an honorary member, his misconduct did not interfere with his success as *a foreigner of merit and reputation.* He is so described in the *Catalogue of* 500 *Celebrated Authors in Great Britain* (London, 1788), and continued his active literary labours without intermission. In 1782 or 1783 he had some appointment as overseer of mines in Cornwall, which he soon after abandoned.

"In 1785 the first edition of *Baron Munchausen's Narrative of his Marvellous Travels*

The prevailing rock is, more or less quartzose, mica-slate;* within short distances of the metalliferous

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Room at Taymouth Castle), MSS. Mac Culloch, *Geol. Trans.*, II. p. 479. Odernheimer, *Quarterly Journal, Prize Essays, and Transactions of the Highland & Agricultural Society of Scotland*, XI. pp. 549—50. Thost, *Quarterly Journal of the Geol. Soc.*, XVI. pp. 425—7. Murchison & Geikie, *Ibid*, XVII. p. 218. Nicol, *Ibid*, XIX. p. 200.

* "The whole tract of country from Killin to Glenorchy in one direction, and from Luss to Loch Tulla at right angles to it, * * * consists of mica slate, and is part of a most extensive district to all appearance formed exclusively of this rock."—MAC CULLOCH, *Geol. Trans.*, II. p. 478.

"The mica slate contains in Glendochart and near Tyndrum the same subordinate strata of talcous, chloritic, and hornblende rocks as on the banks of Loch Tay."—ODERNHEIMER, *Quarterly Journal, Prize Essays, and Transactions of the Highland and Agricultural Society of Scotland,* XI. p. 546.

"Four miles west from the upper end of Loch Tay, at Corycharmaig, the mica-schist contains serpentine, passing in some parts into syenite. As is almost always the case where serpentine appears, it contains chromate of iron. * * * In the same vicinity the mica in the mica-schist is more often than usual replaced

and Campaigns in Russia was published in London by Smith. A second edition came out in the following year, printed at Oxford, but with the same publisher's name upon the title-page, * * *. A third edition published in London in the same year, by Kearsley, bore the additional title prefixed of *Gulliver revived.* In 1787 and 1788 a fourth and fifth edition appeared in England, still without any name of author or compiler.

"In 1787 the work first issued in a German form, with some additional stories under the auspices of the poet Bürger.

"In 1794 Raspe accepted the office of manager of mines at Muckross, co. Donegal, (and) he died in Ireland in the same year.

"In 1824, after Bürger's death, Karl von Reinhard, a friend of Bürger's, first mentioned the true author of Munchausen. *The Collection had,* he writes, *for its compiler the late Professor Raspe, who published it after his flight from Cassel to England.*"

Gentleman's Magazine, CCI., 1856, pp. 588—90 (Abridged).

"At Huel Rock in Saint Agnes, there has been found a metallic vein, nine feet wide, and twenty yards beneath the surface. The constituent parts of this ore, although experiments had been made upon it, were still unknown. Mr. Raspe, who now (1786) lives in Cornwall is the first who discovered this unknown ore to be Sulphurated tin."

KLAPROTH, *Mineralogical and Chemical History of the Fossils of Cornwall*, p. 21.

"Mr. Raspe, who resided in Cornwall about 40 years ago, discovered a vein of the sulphuret of tin from 3 to 5 inches wide, some twenty yards beneath the surface in Huel Rock."

MICHELL, *Manual of Mineralogy* (Published in 1825), p. 73.

"Perhaps thirty years ago the late Captain William Petherick, Manager of Dolcoath, informed me that "*Baron Munchausen's Travels*" had been written by a German whilst he performed the duties of Storekeeper at that mine. Captain Charles Thomas, the present Superintendent of *Dolcoath*, tells me that one of the oldest Mining Captains used often to speak of the wonderful chemical experiments made in the office by Mr. Raspe."

HENWOOD, *Gentleman's Magazine*, CCII. (1857), p. 2.

"*Levels* and *underhand*—or *bottom—stopes*,—the ordinary, and almost the only, mode, of opening mines anciently recognized in the West of England,—have been figured and described

deposit, however, it is succeeded—gradually in some, but suddenly in other, places—by hornblendic slate.*

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by graphite. * * * Further west from the serpentine, several veins of a quartz structure have been found."

Thost, *Quarterly Journal of the Geol. Soc.*, xvi. p. 425.

"At Loch Dochart the schistose or gneissose strata are much gnarled and twisted, dipping in various directions from N.E. to S.E. * * * As we approach Luib the dip appears on the whole north-easterly. There the beds seem undulating along an E.N.E. axis; but they may possibly be reversed to N.W."

Murchison & Geikie. *Ibid*, xvii. p. 218.

"Near Killin, at the head of Loch Tay, the strata, principally mica-slate, mixed with hornblende-slate and limestone, dip at low angles (30°—40°) to N. 25° W. The same dips, though more irregular, continue along Glen Dochart to the limestone near Crianlarich, where there is probably a cynclinal fold."

Nicol, *Ibid*, xix. p. 200.

* "Above, and indeed to a certain extent, interstratified with the talco-micaceous slates of the Lizard, we find well-characterized hornblende slate, occasionally intermingled with beds which have the same mineral composition, but not the same schistose structure. It is a compound of hornblende and felspar, in the mass in nearly equal proportions, * * * The rock is for the most part remarkable for the lustre of its hornblende. * * * The hornblende slate seems intimately connected with the talco-micaceous slates near Poltreath. It supports the great mass of the Lizard serpentine, with an apparent passage of the one into the other in many places."

De la Beche, *Report on the Geology of Cornwall*, &c., pp. 29-30.

by Borlase (*Natural History of Cornwall. Pl. XVIII.*, p. 168) and Pryce (*Mineral. Cornub. Pl. IV.*, pp. 160—72). This wasteful manner of working was the only one followed in Cornwall until (at the earliest) 1778; and as late as 1815 (Carne, *Cornwall Geol. Trans.*, iii., pp. 68—9) it had not been finally abandoned. The (*little winds*) *winze*—variously represented by the same authors—appears to have been so seldom resorted to, that at the *Pool* (*East Wheal Crofty*) mine in 1758 one only, and at *Bullen-Garden* (*Dolcoath*) in 1778 (? 1758), but two such, had been opened. *Back-stopes* are not even mentioned by either of the great authorities on Cornish mining in the last century.

"More than a quarter of a century before Borlase's publication, and nearly half a century earlier than Pryce's, however, the system of *shafts*, *levels*, *winzes*, and *back-stopes* had been both adopted and described in Germany.

"The Mine of *Illmenau* in Saxe Weimar was, thus early, described by Bergmeister Christian Frid Tromler to have been wrought by aid of four *shafts*, six *levels*, and eleven *winzes*; and, at the same time, a section of the mines of Clausthal and Zellerfeld in (the Hartz) Hanover showed nine *shafts*, four *levels*, two *winzes*, two *bottom-stopes*, and eleven *back-stopes*."

Brockmann, *Magnalia Dei in Locis Subterraneis* (Wolfenbüttel, 1730), *Pl. IV.*, *XII.*, pp. 172—6, 255—6.

At *Dolcoath*, in 1783—4, "five hundred pounds per month were spent on timber; and, to draw a kibble of ore weighing about 3 cwt., a new (whim)-rope, of above a ton weight, was worn out in a fortnight."—Smiles, *Lives of Boulton and Watt*, p. 331. "In 1786—8 the Adventurers—believing they had extracted everything worth removal—abandoned the mine; which had reached a depth of one hundred and eighty five fathoms."(—Thomas, MSS. *Ante*, p. 448.) "In 1800, however, the works were reopened; and it was then found that—although

In both, the planes of structure bear nearly S.E.—N.W., and dip 30°—60° S.W.*

Hornblendic slates form the *(hanging and foot walls)* opposite sides of a broad metalliferous band,—the object of pursuit,—which seems to coincide with their lines of cleavage wherever the two are in contact; but the series of low, rocky, hummocks,—visible amid a rank growth of heath and fern for nearly half-a-mile—on the range of its outcrop, bears 20°—30° W. of N.—E. of S.* Openings, more than thirty feet across, have been made in several parts of the formation, but its exact width is still unknown. The principal ingredients—as in the adjoining rocks—are hornblende and felspar; both which are, here and there, distinctly crystallized. Large shapeless bodies of green, brown, and bluish serpentine,—sometimes enclosing, sometimes slightly veined with, diallage,†—appear at intervals. Talc—passing into chlorite and thickly studded with garnets,—abounds in certain parts of the formation; and—under rather different circumstances—steatite and (? tremolite) asbestus are common.

The chromate of iron,—as well in octahedral crys-

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* In 1838 the Magnetic declination was about 27° 30′ West.—Ross, *Phil. Trans.*, CXXXIX. p. 208. Sabine, *Ibid, Pl. XIV.*

† "Within the pier, at Coverack * * * veins of diallage, from 2 to 18 inches wide, and nearly vertical, traverse the serpentine in various directions."
Rogers, *Cornwall Geol. Trans.*, II. p. 420.

the great mass of copper ore they formerly yielded, had been wrought by *bottom-stopes*—the *lode* had been further explored in *levels, winzes, and back-stopes*."(—Rule, MSS. *Ante*, p. 146.)

It appears, therefore,—that the mode of working which had been practised in Hanover and Hesse more than thirty years earlier, was unknown at *Dolcoath* in 1778;—that it was adopted there before 1788;—and that during (1782—3) a portion of the interval, Mr. Raspe, an eminent literary and scientific Hanoverian, was employed on the spot.

tals and narrow interlacing veins, as in angular and rude spheroidal masses varying from a few grains to several tons weight,—occurs in several portions of the deposit; but mostly invested with talcose matter, and always in a vein-stone of serpentine.*

Two series of joints, which bear respectively 25°—30° N. of E.—S. of W., and 15°—20° E. of N.—W. of S., are common to the entire system; but numberless others, of much shorter range, which take almost every direction, are peculiar to the serpentine. All these,—whatever their extent or direction,—show, generally, the mere contact of smooth undulating faces; but sometimes—like the *lodes* and *cross-veins*—they enclose slices of the rock they traverse, or certain of its constituents. Such confronting faces of the strata are often irregularly scored; and the striæ, on opposite sides of the ingredients they occasionally comprehend, have not only different, but, here and there, even contrary, inclinations. Thus the principal joints now and then contain micaceous clay, mixed with granular quartz, whilst they traverse the mica-slate, but are filled, occasionally, with disintegrated felspar, lamellar hornblende, and, sometimes, with (? tremolite) asbestus, when intersecting the hornblendic rocks; both they and the shorter *partings*, however, include serpentine, steatite, asbestus, and talc as they take their way through the several varieties of serpentine. It may be noteworthy that the masses

* Thost, *Quarterly Journal of the Geol. Soc.,* XVI. p. 425. Smyth, *Ibid,* XXIII. p. LXII.

(bunches) of ore are seldom alike in quality*—frequently, indeed, their forms are dissimilar†—on opposite sides of the joints.

From 1855 to 1860 some seventy tons of ore were quarried, of which nearly thirty realized about five pounds and two shillings (£5 : 2 : 0) per ton,‡ and (in 1861) forty remained unsold; whilst great quantities—yet unwrought—were still visible at the surface.§

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* "Not a few of the larger and richer *bunches* of ore have been found exclusively on one side of *cross-veins*; whilst on the opposite side the same lode has been entirely worthless."—HENWOOD, *Cornwall Geol. Trans.*, v. p. 233.

† "The parts of *lodes* in contact with the opposite sides of *cross-veins* have [sometimes] scarcely the faintest resemblance in contour to each other." *Ibid*, p. 381.

‡ J. F. Wyllie, Esq., Factor to the late Marquis of Breadalbane, MSS.

§ "Chromic iron is found abundantly in the Heathcote Creek and Argyle Gully, near Mc Ivor, and reported from Riddell's Creek, near Mount Macedon, forming a fine black sand, wholly composed of minute, exceedingly sharp octahedrons. It also occurs, finely impregnated in quartz reefs and quartzose rocks, near Heathcote, Strathlodden, &c."—SELWYN and ULRICH, Intercolonial Exhibition, 1866. *Notes on the Physical Geography, Geology, &c. of Victoria*, p. 53.

Notes on the Molybdenite of Tomnadashan in Perthshire.

At Tomnadashan, about midway between Killin and Kenmore, the southern shore of Loch Tay consists of mica-slate; * in portions of which the several ingredients occur here and there in separate concretions,† whilst, generally, the rock is of coarse grain and thick lamellar structure.

The mica-slate is traversed 25°—30° W. of N.—E. of S. ‡ by a band of great, but unequal, width, consisting chiefly of felspar, hornblende, chlorite, and quartz; § which constitute felspar-porphyries in some, but greenstones (diabases) in other, parts; the former

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* "The mica-slate near the south side of Loch Tay has a northern underlay, but much flatter than on the north side of the lake; sometimes it is almost horizontal, then changing in a short distance to a southern dip, and soon again to the north; so that the strata appear like waves, showing, however, a prevailing northern underlay."—Odernheimer, *Quarterly Journal, Prize Essays & Transactions of the Highland and Agricultural Society of Scotland*, xi. p. 546.

† "Near Craig Cailleach, on the northern side of Loch Tay, the mica slate is traversed by veins, and interspersed with compressed nodules, of quartz, which bear no marks of attrition, but are intimately united to the [rock] in which they occur."—Mac Culloch, *Geol. Trans.*, ii. p. 437.

‡ *Ante*, p. 647, Note *

§ "The igneous rocks on the south side of Loch Tay are chiefly composed of compact felspar-porphyry, in the most striking variety, and of greenstone. Both rocks, porphyry and greenstone, are closely connected at Tomnadashan. * * * At this place there is quite a mixture, each forming veins and nodules in the other. This mixture occurs in the middle of the * * * greenstone and porphyry. Towards the borders of the space occupied by these rocks, a separation takes place, the greenstone occupying the east side, the granitic porphyry the west. It is not very possible to ascribe a previous age either to greenstone or to porphyry; they seem to be contemporaneous: and the veins of greenstone in porphyry, and of porphyry in greenstone, may be veins of secretion, or an accumulation of similar masses out of a mixed compound of minerals."

Odernheimer, *Quarterly Journal of the Highland and Agricultural Society of Scotland*, xi. pp. 542—3.

enclosing—as the *Elvans* of Cornwall often enclose,* —isolated crystals of felspar are mostly, though not always, determined to the middle, the latter towards the sides, of the formation. Bodies of either rock, however, enwrap shapeless masses, and are penetrated by strings, of the other; each, in turn, thus becoming the envelope and the enclosure,—the *country* and the vein; meanwhile all are, more or less, sprinkled and veined with quartz. Between the mica-slates, porphyries, and greenstones the transition is often gradual; but frequently the passage is abrupt and immediate.

Amongst several series of joints common to this system, the best marked and most numerous—

(1.) bear 25°—30° W. of N.—E. of S.;—are nearly parallel to the *strike* of the mica-slate, but *range*, as well transversely to the felspathic and hornblendic rocks, and to the second series of joints, as obliquely to the joints of the third and fourth series.;—

(2.) „ 25°—30° N. of E.—S. of W.;—are nearly parallel to the *strike* of the felspathic and hornblendic rocks; but *range* as well transversely to the cleavage of the slate and to the first series of joints, as obliquely to the joints of the third and fourth series;—

"Near the middle of the south side of Loch Tay, opposite Ben Lawers, at the Tomnadashan mines, * * * the greenstone, while remaining unchanged in position and character on the east and west sides, * * * has near its middle not only been deranged by * * * a powerful vein of porphyry, but has also been often altered into a substance exhibiting the mixed characters of greenstone and porphyry, with transitions from one to the other."

Thost, *Quarterly Journal of the Geol. Soc.*, xvi. p. 422.

* "At Pra-sand, near Marazion, the *Elvan*, though equally crystalline, is sometimes fine-grained on the outside, whilst in the centre it is coarser and more decidedly porphyritic."—Henwood, *Cornwall Geol. Trans.* v. pp. 51, 162.

Sedgwick, *Cambridge Phil. Trans.* i. p. 129. Boase, *Cornwall Geol. Trans.* iv. p. 354. *Primary Geology*, p. 57.

(3.) bear 15°—20° E. of N.—W. of S.;—are oblique as well to the cleavage of the slates and the *range* of the felspathic and hornblendic rocks as to the first and second series of joints, but are transverse to the joints of the fourth series;—

(4.) „ 15°—20° S. of E.—N. of W.;—are oblique as well to the cleavage of the slates and the *range* of the felspathic and hornblendic rocks as to the first and second series of joints, but are transverse to the joints of the third series.

Less developed joints take other directions, in many—and especially in the porphyritic—parts of the system.

Some sixty fathoms above, and two hundred south of, Loch Tay extensive operations were carried on, for many years, at a heavy loss, by the late Lord Breadalbane,* on two *lodes*, which traverse both the greenstone and the porphyry, obliquely, as well to their boundaries as to one another.†

The westernmost *lode* bears nearly S.E.—N.W., and dips 70°—80° S.E.,—
whilst the easternmost „ „ some 25°—30° S. of E.—N. of W. „ W.—N.W.;

but, notwithstanding this convergence,—no less in their descent than in their course towards the S.—

* *Ante*, p 643, Note †

† "At Tomnadashin * * * the veins contain rich copper-pyrites, iron-pyrites, and some sulphuret of molybdena. The veins which contain quartz or calc-spar yield grey copper-ore, rich in silver and copper; from these a great number of branches are sent off in all directions."

Odernheimer, *Quarterly Journal of the Highland and Agricultural Society of Scotland*, xi. p. 528.

"In the mines of Tomnadashan several * * * divisions, which have received the general name of *clay-veins*, may be seen, forming very regular courses both in perpendicular and horizontal directions, They are receptacles of * * * silver-ore, copper-pyrites, grey copper-ore, iron-pyrites, and molybdenite."

Thost, *Quarterly Journal of the Geol. Soc.*, xvi. pp, 422—3.

S.E.,—operations have never been extended to their contact.* In width they vary from about six inches to nearly four feet.

Whilst traversing the greenstone, their principal earthy constituents are felspar and hornblende; but, in the porphyry, they consist chiefly of felspar and granular quartz; everywhere, however, massive quartz is a large ingredient, and smaller quantities of calcareous-spar and of chlorite are not uncommon.

As the *lodes* converge, the rock between them is intersected, in every imáginable direction, by numberless intertwining veins of felspàthic, quartzose, hornblendic, calcareous, and chloritic matter; usually a mere fraction of an inch, though sometimes several feet, in thickness. But, notwithstanding these interlaced portions may not transgress the limits of the greenstone formation, the general prevalence of hornblende within them, and of felspar towards their surfaces, gives the entire mass a brecciated character.

Both the *lodes* and their *branches*† contain, near the surface, great quantities of earthy brown iron-ore, small *bunches* of copper-pyrites, and nests filled with earthy black copper-ore or studded with malachite; downward, however, the earthy ore is gradually replaced by iron pyrites; yellow copper-ore becomes

* "When the miners are working along on the course of a lode, ever so good, and they find it separate and diverge into branches or strings, it is a great sign of its poverty; but, on the contrary, if they are driving on branches of ore, and they find them embodying or coming together, as they work on the course of the lode, it is promissing."—Pryce, *Mineralogia Cornubiensis*, p. 103.

† *Ante*, p. 652, Note †.

more plentiful, and granules of fahlerz together with particles of galena are thinly sprinkled through the matrix.

The sulphuret of molybdenum—masked, possibly, by other substances—is seldom observed *in* the *lodes;* but—accommodating itself to the striæ, which score the vein-stones and the *(Country)* rocks at their contact—it, not uncommonly, shows itself as a slickenside. On the margin of the lake, however, small tabular crystals are scattered through the porphyry and face its joints.*

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‡ Molybdenite occurs on the Syenite (or granite) of Mount Sorrel.
Foster, *Geological Magazine*, iii. p. 525.

"Fine hexagonal plates of Molybdenite, with the terminal edges replaced, and of from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in diameter, occur thickly embedded in a quartz vein traversing granite at Yackandandah; it also occurs in a similar manner at Reedy Creek, and very sparingly dispersed in small scales through the granite at the breweries near Maldon. The Yackandandah mineral contains, according to assays, a small per-centage of silver."—Selwyn & Ulrich, *Notes on Physical Geography, Geology, & Mineralogy of Victoria* (Intercolonial Exhibition), p. 59. Smyth (R. Brough), (Intercolonial Exhibition Essays) *Mining and Mineral Statistics*, p. 33.

Daubrèe, *Annales des Mines*, 4me Série, iv. p. 233. *Ante*, p. 546.

The Caradon District in East Cornwall comprises—those parts of the parishes of Saint Cleer and Linkinhorne which are enclosed by a line drawn from the village of Saint Cleer to Henwood on the N.N.E.,—continued thence to Bodmin-land (a part of Caradon-down) towards the S.S.E.—and returned, through Trethevy, to Saint Cleer on the W.S.W.;—an area exceeding four square miles.

Detached portions of the district had been described by several earlier observers,* but a general outline of its structure was first sketched by Dr. Boase in 1832;† further detail was published by Sir H. T. De la Beche in 1839;‡ and much, that had escaped his predecessors, was carefully worked out by Mr. Whitley in 1845.§

The rocks consist of granite,†‡§—slate †‡§ interlaid by hornblendic beds,†‡§—and elvan § intersecting both granite and slate; their several junctions, however, are much concealed by soil and vegetation.

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* Carew, *Survey of Cornwall*, p. 129. Borlase, *Natural History of Cornwall*, p. 113; *Antiquities of Cornwall*, p. 173. Pryce, *Mineralogia Cornubiensis*, p. 34. Polwhele, *History of Cornwall*, I. p. 174. Mac Culloch, *Geol. Trans.*, II. p. 69, *Pl. IV.* Lysons, *Cornwall*, pp. CLXXXIV., 198. C. S. Gilbert, *Historical Survey of Cornwall*, I. p. 172; II. p. 479. Hitchins & Drew, *History of Cornwall*, I. pp. 52, 144; II. p. 154. Bond, *History of Looe*, pp. 195, 204. Rogers, *Cornwall Geol. Trans.*, II. p. 218.

† *Cornwall Geol. Trans.*, II. pp. 208—11, *Pl. II.*

‡ *Ordnance Geological Maps*, *Report on the Geology of Cornwall, Devon, & West Somerset*, pp. 79, 159,—85.

§ *Geological Map of the Caradon Mining District.*

The writer thankfully acknowledges the advantage he has derived from this excellent work; of which a copy was—before his first visit to Caradon—obligingly presented to him by Mr. Whitley.

The contact of the granite and slate bears N.E., in two railway-cuttings, near Trecarne; and thence, by a sharp recurvature to the W., it reaches the head of Tremar-coombe; whence, an E.S.E. course brings it to Hendra, and afterwards to the N. of Crow's-nest: a deep creek in the granite being—so to speak—thus filled with slate.* † From Crow's-nest the line of junction—slightly undulating as it skirts Stanton and passes through Bladda—trends about E.N.E. almost to the Liskeard and Launceston turnpike; but thence it is deflected towards the E.S.E. From this (the E.) extremity of the granite, the line of union keeps a N.N.W. course beyond Tokenbury, veering, however, to the N.N.E. on approaching Yeoland; and thus—as it were—filling with slate a broad granite-bounded bay directly E. of Caradon. From Yeoland the boundary—bearing W.N.W.—winds round the hill-side above (S. of) *Marke Valley*; but nearly opposite Shilston's gate (Mutton-corner) it suddenly swerves towards the N., and—displaying remarkable alternations, at *(Clanacombe) Phœnix*, in the interval—keeps its way to Knowl; for some distance, however, this line is merely the E. margin of an offshoot, from about thirty to perhaps two hundred fathoms in width, which separates from the mass at Caradon but reunites with it beyond Newland. From Knowl its path is not easily traced; but, for nearly a furlong W. by N. of

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* *Ante*, p. 655, Note §.

† This inflexion is not shown on the *Ordnance Geological Map*.

granite,*—accompanies the *Sharp Tor lode*, but at different levels on opposite sides.†

But, beside the schistose rocks which skirt the granite on the S., S.E., E., and N.E., a tract of slate —some seven furlongs in length by three and a half in breadth—is represented‡ as completely insulated; by the granite slope which culminates in the Cheesewring on one side, and by the broad band of granite which extends from Caradon, through Shilston's-gate, to Knowl on the other. That this stretch of granite separates—during a considerable part of its course— the comparatively small patch of slate on the W. from the great body of schistose rocks towards the E. seems unquestionable; but that, throughout its entire range, it absolutely severs one mass of slate from the other, neither observations at the surface, nor mine-works at the contact of the granite and slate, have yet conclusively proved. Within the boundaries assigned‡ to this strip of ground, in fact, the S. upper side of *(hanging-wall)* the *Phœnix lode* § to about thirty-five fathoms from the surface consists of slate; whilst the confronting portion of the N. lower *(foot-wall)* side, and both sides *(walls)* at all greater depths, are composed wholly of granite. The shallower parts of other *lodes* in the immediate neighbourhood seem likewise bounded by slate on their (S.) upper, but by

* *Ante* p. 656, Note †.

† Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 67.

‡ *Ante*, p. 655, Notes ‡ §.

§ *Table XXV.*

granite on their (N.) lower sides.*† What thickness of

* The late Captain Samuel Seccombe, who long managed the *Phœnix* mines, maintained that throughout this particular part of the district, the shallower parts of most of, if not of all, the *lodes* were bounded by slate on their upper *(hanging)*, but by granite on their lower *(foot walls)*, sides.

† At *Cook's-kitchen* "the first 15 fathoms of the shaft, in which the pumps are worked, are in superficial *growan*; the 20 fathom following are in *killas*; under which 13 fathom are again in *growan;* thence, for a certain space, * * * the *load* has the *growan* on one side and the *kellas* on the other. * * * From this, down to a certain depth, similar differences are found between the *strata* opposite to each other on the sides of the *load,* which afterwards passes into *granite.*"—De Luc, *Geological Travels*, iii. p. 293.

Thomas, *Survey of the Mining District from Chasewater to Camborne*, p. 10, Hawkins, *Cornwall Geol. Trans.*, ii. p. 378. Sedgwick, *Cambridge Phil. Trans.*, i. p. 122.

The characters of the rocks, which form the confronting sides *(walls)* of several of the *lodes*, at different depths in *Cook's-Kitchen* are shown in the following columns:—

Lode. Name.	Dip	Depth. fms.	North side. *Hanging* (upper) *wall.*	North side. *Foot* (lower) *wall.*	South side. *Hanging* (upper) *wall.*	South side. *Foot* (lower) *wall.*
South	S.	54	....	Slate	Granite.	
Toy's	N.	54	Slate ..	....	....	Granite.
Dunkin's	S.	48	....	Granite ..	Slate.	
		55	....	Slate	Granite.	
		68	....	Slate	Granite.	
Middle Engine..	N.	33	Slate ..	....	....	Granite.
Hard Shaft	N.	54	Slate ..	....	....	Slate enclosing masses of granite.

"In the S. part of *Cook's-Kitchen* a decomposing granite appears at the surface and continues downward for about 13 fathoms, where it is succeeded by slate which reaches to a depth of 39 fathoms. From 39 to 49 fathoms fine-grained schorlaceous granite prevails; and for a great many fathoms downward beds and masses of granite and slate irregularly mix and alternate in a very irregular manner; * * * in most, if not in all, cases, veins of granite traverse the slate."
Henwood, *Phil. Mag. & Annals*, x. (1831) pp. 358—63; *Cornwall Geol. Trans.*, v. pp. 58, 61, 148,—50, *Table LI.*, *Pl. VI.*, Fig. 4, 5. (Abridged.)

At *Tincroft* "granite was found on one side of *Dunkin's lode* and schist on the other."—William Phillips, *Geol. Trans.*, ii. p. 154, *Pl. VII.*, Fig. 8.

"In *Tincroft* a mass of granite accompanies *Dunkin's lode* from the surface

schistose rock may form each of such upper *(hanging-wall)* S. sides ; or whether all, any, or either, of them, may intersect the entire band of granite and thus connect the small (W.) patch with the great (E.) body of slate, has never yet been ascertained.

At *Sharp Tor*—as in the *Phœnix* mines—shallow portions of the *lode* are bounded by slate on the S. upper *(hanging-wall)* side, but by granite on the N. lower *(foot)*.*

At *Marke Valley*,† some three-quarters of a mile S.E., however, the *lode*—which dips towards the N.—is accompanied on its N. or upper *(hanging-wall)* side,

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to 26 fathoms deep; but, at a short distance on each side of this granite, as well as in both *walls* of the *lode* from 26 to 84 fathoms deep slate is the only rock."

Henwood, *Cornwall Geol. Trans.*, v. pp. 60, 198, *Table LII.*, *Pl. VI.a*, Fig. 1, 2.

"At *Wheal Trannack* the *lode*, at 34 fathoms deep, continues for 10 fathoms with granite on the S, *(hanging)* wall, and slate on the N. *(foot)*."

Ibid, pp. 51, 197, *Table XLVI.*

In the *Providence Mines*,—

At 58 fms. deep	the granite in the S.E.	or upper (*hanging-wall*) side	is 6 or 8 fms. further N.E. than in the N.W. or lower (*foot-wall*) side.
,, 76 ,,	the granite in the N.W.	or lower (*foot-wall*) side	,, 10 ,, ,, N.E. than in the S.E. or upper (*hanging-wall*) side;
,, 86 ,,	, however, the junction of the granite and slate occurs in confronting parts of the opposite walls.		

Ibid, pp. 18, 196, *Table XXI.*

"In *Botallack* the *Wheal Hazard lode*, at 60 fathoms from the surface, runs about 20 fathoms between granite on the S. or upper *(hanging-wall)* side, and slate at the N. or lower *(foot)*."—*Ibid*, pp. 8, 196, *Table VII.*

Carne, *Ibid*, ii. pp. 92, 319.

* "The eastern shaft is being sunk in [the] tongue of killas, which runs up to within eighty fathoms of the engine-shaft; where, at the seventy fathom level, it underlies west at an angle of 45° *under the granite*. * * * The transition from killas to granite is so defined, that it can be pointed out to half an inch. * * * The lode for a considerable distance separates the granite from the killas."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 67.

† *Table XXVI.*

to a depth of thirty-six fathoms, by slate; but in the immediately opposite parts of its S. or lower *(foot-wall)* side, and at greater depths on both sides, by granite.

It seems, therefore, that whether the *lodes* of this district dip N. or S., the shallower parts of their upper *(hanging-wall)* sides are of slate; whilst the immediately confronting portions of their lower *(foot-walls)*, as well as both their sides *(walls)* at greater depths, are of granite.*†

Isolated masses‡ and *courses*§ of *elvan* are common, to both the granite and slate, in many parts of the district; but—from the abundance and excellence of the granite, which, being more readily and cheaply obtained, is generally used as a building-stone—the *elvan* is less frequently quarried, and its relations are, perhaps, less understood, in this than in any other of the western mining-fields.

The best-known of the Caradon *elvan-courses*—bears 15°—25° S. of W.—N. of E.,|| — crosses Tremar-coombe at the *Tremar* mine, — reappears near the Trethevy-stone,¶—and passes through Trenoweth; but

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* *Ante*, p. 658, Note †

† "The *slip*, or plane of dislocation hades, dips, underlays, or is inclined to the vertical so as to pass under the depressed portion of the strata which are displaced."—Professor Phillips, *Illustrations of the Geology of Yorkshire*, ii. p. 111, *Pl. XXIV.*, *Figs.* 16, 17; *Ante*, pp. 72, 227, Notes.

‡ *Tables XXIII.—IV.*

§ *Infra. Postea*, p. 661.

|| Whitley, *Geological Map of the Caradon Mining District.* Giles, *Cornwall Geol. Trans.*, vii. p. 158.

¶ Although this fine cromlech is made of unhewn granite (Norden, *Topo-*

whilst maintaining—though at a distance of two or three furlongs—a general parallelism to the granite, it is traced through the slate series only.

A second *elvan-course*, bearing 10°—15° S. of W.—N. of E., emerges from the granite between Trecarne and Hendra; but, after traversing the slate for about five furlongs, it re-enters the granite near Crow's-nest.

A third *elvan-course*, which bears 25°—30° S. of W.—N. of E., has been followed through the slate immediately S. of Caradon-cot, and opened in several *levels* at *Marke Valley.**

Other *elvans* occur in different parts of *West Caradon*, *South Caradon*, and *Caradon-hill;* but—if they are not, really, isolated masses †—no connexion between them has been yet satisfactorily traced.

The hornblendic and felspathic rocks of Saint Cleer Down, Tremar-coombe, and Trethevy, which interlie the slate but never reach the granite, have been long

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graphicall & Historical Description of Cornwall, p. 88. Lysons, *Cornwall*, CCXIX. C. S. Gilbert, *Historical Survey of Cornwall*, I. p. 173. Hitchins & Drew, *History of Cornwall*, I. p. 174. Bond, *History of Looe*, p. 216. *Beauties of England and Wales*, II. p. 389. Davies Gilbert, *Parochial History of Cornwall*, I. p. 193. Pattison, *Reports of the Royal Institution of Cornwall*, XXXII. (1850), p. 31. Pedler, *Reports of the Penzance Nat. Hist. Society*, I. p. 435. Allen, *History of Liskeard*, p. 5, *Pl. II.* Blight, *Ancient Crosses, &c., in the East of Cornwall*, p. 130. *Complete Parochial History of Cornwall* (1867), I. p. 205.) it stands nearly half-a-mile within the boundary of the slate formation.

* *Table XXVI.*

† "Within six feet of the lode [at West Caradon] the country softens, and is intermixed with * * * porphyritic elvan, which sometimes thrusts itself into the lode."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 36.

[In South Caradon] "there is nothing that can be called an elvan course, although numerous patches occur near the lode and favourably affect it."

Ibid, p. 33.

recognized and often described; * yet, whether they form isolated masses,—are portions of one and the same body,—or even touch the *elvan*, is still unknown.

(*a*.) The granite consists generally of felspar, quartz, and mica; towards the boundary, however, it is often thinly sprinkled with schorl; within certain distances of the *lodes*, it sometimes contains chlorite, and smaller quantities of fluor occasionally appear.† The quartz is always, more or less, translucent; the felspar in

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"In many of the mines are found irregular masses of elvan of different degrees of hardness, scattered at various depths."—Thomas, *Survey of the Mining District from Chasewater to Camborne*, p. 17.

"I have myself seen no large masses [of elvan] so situated as to leave no uncertainty respecting them."—Henwood, *Cornwall Geol. Trans.*, v. p. 166.

* "The hornblende formation of St. Clere is principally confined to that elevated land called St. Clere Down. It extends about a mile from E. to W., and about half-a-mile from N. to S., and appears to run E. & W., and to dip towards the S. or S.W. * * * Although the St. Clere Down formation is distinctly bounded, hornblende is also frequently to be found in other parts of this and the neighbouring parishes. * * * At Cradock Mill is a quarry of hornblende-slate, dipping S.E.; and in the valley below Tremar, a large mass of rock called Watertor, consists of dull, fine-grained hornblende. * * * On Forsnooth Down, and again towards the E. near Trevethy-stone, hornblende and hornstone are found."—Rogers, *Cornwall Geol. Trans.*, ii. pp. 218—20.

"The large down between Liskeard and St. Cleer, is composed of hornblende-slate, and is strewed over with bowlders of greenstone."—Boase, *Ibid*, iv. p. 208.

De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 79. Whitley, *Geological Map of the Caradon Mining District*. Giles, *Cornwall Geol. Trans.*, vii. pp. 156,—8.

"The bed of volcanic rock at St. Cleer on the south [bears] very much the same relation to the granite that that of Alternum does on the north, lower rocks being brought up in the interval on the east of the granite at Caradon" * * *. Holl, *Quarterly Journal of the Geological Society*, xxiv. p. 421.

† "Towards the top of Downhill is a fine-grained granite, in which [snow-white quartz, shorl, and mica] are so intimately united, as to form a granular basis, having imbedded crystals of flesh-coloured felspar. Coarse layers also occur containing more quartz, shorl, and mica, than felspar. * * * On Carraton Hill are several extensive excavations * * * in a fine-grained granite, the upper part of which is partially decomposed, being of a reddish brown colour,

great part of the district is of milk-white hue, but on the outskirts and near the *lodes* it assumes many shades of pink, buff, and brown; the mica is perhaps rather more frequently black than either brown or white, but occasionally all three sorts happen together. The felspar and quartz are, for the most part, either separately aggregated or intimately mixed, but now and then masses of either are enveloped in bodies of the other; mica and schorl, in much smaller proportions, are scattered indifferently through both, and sometimes spiculæ of schorl are imbedded in felspar at one end and in quartz at the other. But, notwithstanding the whole body is crystalline its constituents rarely form entire and perfect crystals; it is true that portions of the felspar, here and there, develope distinct planes and

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and porous, not unlike some kinds of brick. This rock is derived from a very compact granite, consisting of minute grains of red felspar and quartz, with a greenish mineral resembling hornblende."

Boase, *Cornwall Geol. Trans.*, iv. pp. 209—10.

"The granite of the Brown Willy district is very similar to that of Dartmoor, its principal mass being a mixture of quartz, felspar, and mica, the latter sometimes white, at others black, the two micas occasionally occurring in the same mass, and being frequently porphyritic from the occurrence of large crystals of felspar disseminated through the aggregate. As a whole it is not particularly schorlaceous, though here and there schorl may be discovered in small crystals in the mass. It appears chiefly so towards the south. Near St. Cleer there are some interesting schorlaceous rocks composed of quartz, schorl, mica, and felspar."

De la Beche, *Report on the Geology of Cornwall, Devon, &c.*, pp. 157,—9.

"The primitive granite of Caradon hill is bordered as well on the south as on the west towards Craddock Moor by productive granites, of rough and irregular fracture; divided by many joints, frequently containing hornblende or chlorite, and traversed by regularly formed *elvan-courses*. But this gets thinner and thinner as it recedes from the primitive hill, until hard granite, without sign of metallic life of value, fills up the rest of the district."—Charles Thomas, *Remarks on the Geology of Cornwall and Devon*, p. 15. (Abridged.)

angles, yet these—interfered with by less regular faces—gradually disappear in the mass.* Elsewhere than in Cornwall this granite would, probably, be considered coarse-grained; it is, however, much less so than that—bounded by hornblendic and felspathic rocks—in the Saint Just and Saint Ives districts.†

But, beside the ordinary and occasional ingredients already mentioned, tin-ore is sometimes scattered through the rock, and—as near Two-bridges on Dartmoor,‡ Raggy-rowal in Breage,§ *Carclaze* and the *Bunny* near Saint Austell,|| and *Balleswidden* in Saint Just ¶—forms one of its constituents. Within short distances of certain well-known *cross-courses*,** a body of this tin-bearing granite has been wrought at the foot and on the slope of Caradon;

from Gonamena N. for quite 330 fms. in length and 50—in extreme breadth; ††						
and on either side offsets have been followed;						
towards the W. for	40	„	„	„ 25	„	;
and „ E. „	150	„	„	„ 70	„	.

* Henwood, *Cornwall Geol. Trans.*, v. p. 221.

† Carne, *Ibid*, III. p. 210. De la Beche, *Report on the Geology of Cornwall, Devon, &c.*, p. 160. Henwood, *Cornwall Geol. Trans.*, v. p. 26.

‡ Berger, *Geol. Trans.*, I. p. 120. *Ante*, p. 175.

§ Henwood, *Cornwall Geol. Trans.*, v. pp. 53, 235—6.

|| Jars, *Voyages Métallurgiques*, III. p. 190. Carne, *Cornwall Geol. Trans.*, II. p. 92. Boase, *Ibid*, IV. pp. 238—9. Hawkins, *Ibid*, IV. p. 476. Sedgwick, *Proceedings of the Geol. Soc.*, I. p. 283; *Phil. Mag & Annals*, IX. p. 284; *Geol. Trans.* N.S., III. p. 483. Von Oeynhausen & von Dechen, *Phil. Mag. & Annals*, v. pp. 241—2. De la Beche, *Report on the Geology of Cornwall*, &c., p. 346. Henwood, *Cornwall Geol. Trans.*, v. pp. 120, 235.

¶ *Ibid*, pp. 15, 235—6.

** De la Beche, *Ordnance Geological Maps*, Sheet XXV. Whitley, *Geological Map of the Caradon Mining District.*

†† "There is an immense excavation, commencing a little to the south of the

The area of this opening is about eleven acres;* but it is nowhere more than eight fathoms in depth.†

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new engine-shaft, and extending in a northerly direction across the *sett* [of Gonamena], where it takes a bend to the eastward. This has for ages been streamed for tin to a great depth, but latterly it has been worked by an adit brought up from some distance down the valley. Judging from appearances, very considerable and profitable returns must have been made."

Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 52.

* Nicholas Whitley, Esq., C.E., Secretary of the Royal Institution of Cornwall, MSS.

† The *open-work*

at *Wheal Music*	which is nearly	25 fms. deep,	measures about	1·		acre in area.
„ *Carclaze*	„	25 „	„	5·		acres „ .
„ *Mona* in Anglesea	„	18 „	„	5·331	17·462	„ „ .
„ *Parys* and *Mona*.	„	23 „	„	12·131		

Henwood, *Cornwall Geol. Trans.*, v. pp. 98, 120. Thomas, *Ibid*, p. 120. *Ante*, p. 576.

At *Fahlun* in Sweden an accident to the more ancient works opened to the surface, on the 24th June, 1687, a chasm 163 fathoms in extreme length, 128 in breadth, about nine acres and a half in area, and 43 fathoms in depth.

Jars, *Voyages Métallurgiques*, III. p. 38, *Pl. II. Fig.* 1, 2. Thomson, *Travels in Sweden*, p. 217, *Pl. IX. X.* De Villefosse, *Richesse Minérale*, II. p. 315, *Pl. XIX. Fig.* 1, 2. Clarke (E. D.), *Travels in various Countries*, X. pp. 526,—33. Hawkins, *Cornwall Geol. Trans.*, III. pp. 271,—3. Daubrée *Annales des Mines*, 4me Série, IV. pp. 238—42, *Pl. VI. Fig.* 20, 21.

" The famous stockwork of Geyersberg [in Saxony] is nothing else than a large mass of the mountain impregnated with tin-stone, occasioned by the meeting of a number of lodes and veins, some of these crossing each other at various angles, others stretching in a parallel or nearly parallel direction. * * * The veins are chiefly of quartz, and are united to the rock in such a manner as to indicate their coeval formation. It is remarkable, however that the tin lies for the most part unequally dispersed through the latter; and this circumstance has given occasion to * * * the great irregularity which appears to have marked the progress of the excavations from their commencement. This defect in the plan of operation has been carried to the most pernicious excess, [for] the immense excavations, and the little attention paid to the support of the rock above, brought on the fatal catastrophe of 1611, when the whole extent of country which had been undermined, including an area of some acres on the side of the mountain, sunk in at once to a depth of 100 feet, and involved a considerable part of the rock in ruin. Wherever the rock is sufficiently rich in tin * * * openings are still made by wood-firing; * * * the capacity of one of these (the Christopher) is equal to that of a cathedral; but it is apprehended that [disregard of the ordinary precautions] will at no distant period cause a recurrence of the former catastrophe. The rock itself is a variety of porphyry, the mass being a mixture

A similar—but a smaller—*work* occurs about two furlongs S.S.W. of the Cheese-wring.*

The granite of this district is largely quarried; some ten thousand tons a year† being now taken by railway from the Cheese-wring to Looe for exportation.

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of chlorite earth and clay, in which the grains of felspar and quartz are scarcely perceptible."—Hawkins, *Cornwall Geol. Trans.*, ii. pp. 39—42.

The subsidence which took place at *Dolcoath*, in 1828, affected, perhaps, a larger sectional area than that at *Fahlun;* but it neither extended far from the *lodes*, nor reached the surface (*Report on the Geology of Cornwall*, &c., Rule, *Pl. VIII. IX.*). The movement—which continued for several weeks,—was so slow that workmen who, at its commencement, were employed in deep E. (*levels*) galleries—by climbing uncrushed portions of the ladders in some places, and waiting opportunity and creeping through crevices between moving rocks elsewhere—reached the surface at the W. part of the mine in safety. "The vacuities occasioned by the removal of the vein-stuff [having] been filled up as much as circumstances permitted, * * * the general fall did not exceed a few inches; but large masses of rock were detached from their places, and interrupted the working of the pumps" (Airy, *Phil. Trans.*, cxlvi. (1856) p. 299). During the settlement great quantities of ancient rubbish were taken from the surface in order to fill the openings underground; and, after it had ceased, some thousand loads of timber were used for keeping open the requisite communications; in some cases, however, it was deemed unsafe to attempt propping the overhanging sides of the larger cavities, until inaccessible and dangerous crags had been brought down by cannon-shot.

* *Ante*, p. 664, Note **.

† "The excellent fine-grained granite of the Cheesewring hill being rendered accessible by the Liskeard and Caradon Railway which reached its base, a company was soon formed to work it, and exported considerable quantities * * *. The carriage of granite down the railway in 1854 amounted to 3,364 tons, and it is likely to be greatly increased."—Allen, *History of Liskeard*, p. 402.

The Cheese-wring quarry presents a rude semicircular section of the hill-side, some four hundred feet in width by one hundred in depth. The granite it affords—if inferior to any in Cornwall,—is second only to that of Carnsew near Penryn, in the uniformity of its texture and hue. The rock forms beds of great extent, but of unequal thickness; those of the finest grain being, usually, uppermost and thinnest. Single explosions will sometimes displace masses of a thousand tons each; but such are divided into pieces of manageable sizes by smaller blasts. The blocks are cleaved by boring, at intervals of about three inches, holes some three inches deep;—placing a pair of thin iron plates (*feathers*) in each hole,—and between each pair a wedge, a very few blows, with a heavy hammer, on each wedge, suffice to split the rock, tolerably smoothly, in the required direction.

(*b.*) The slates consist—as the granite they adjoin also consists *—chiefly of felspar and quartz; mixed, however, with mica in some, and with chlorite in other, places.† They vary from bluish-black to pale-blue, light-green, greenish-white, greyish-buff, pinkish-grey, and brick-red, in colour; and from thick-lamellar to fissile in structure.

At its contact with the granite, immediately N. of Crow's-nest, the slate is thick-lamellar, and of greenish hue.

At Bladda and Tokenbury the slate, within short distances of the granite, is still of thick-lamellar structure; but its hues—though purplish in some, and brownish in other, places—are generally of pale blue. In the deeper parts of *Marke Valley* the granite is

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Upwards of one hundred men and boys are employed on the works; and about ten thousand tons of granite are annually conveyed by railway from the quarry to Looe, whence it is exported. From Mabe and Constantine, however, nearly thirty thousand tons a year are shipped at Penryn and Port Navis.

Western Daily Mercury (28th May,—2nd June, 1868), xv. No. 2463, 2467. (Abridged.)

* "The granite and slate of Cornwall, at their junction, are frequently so similar, both in composition and concretionary structure, that * * * at a little distance they cannot be distinguished from each other; the darker colour of the slate, and its tendency, often slight, to break into laminæ, are sometimes the only differences to be detected on a closer inspection."

Boase, *Primary Geology*, p. 132.

† "The argillaceous strata mainly consist of yellowish-brown slates, sufficiently soft to be wrought * * * for building purposes. But though this is the prevailing characteristic of these slates, it is not the only one, for they are found in many places to pass gradually into a greenish-coloured schist, apparently from an admixture of chlorite; and then again into grey, and light and deep blue coloured schist, varying in degrees of hardness and cleavage [but] these exceptional beds occur at wide intervals. * * * Leaving St. Cleer down on the south-western side, and following the line of dip, the strata vary with brown and dull grey coloured beds; the brown being the softer and least fissile of the two."—Giles, *Cornwall Geol. Trans.*, vii, p. 155.

succeeded by a compact, pearl-white, felspathic rock; and this graduates into thick-lamellar slate; at first of greyish-blue, but afterward of purple, hue.* Nearer the surface, but further from the granite, greenish tints prevail in the, rather fissile, slate, but sometimes it is mottled with buff or reddish-brown; at intervals, however, it is interlaid by beds of thicker structure, and in these pinkish flakes and dark-green granules are scattered through a basis of pale-green.

Fragments of purplish-red, reddish-brown, greenish-grey, and pearl-white quartzose slate thinly flecked with mica,—probably the refuse of ancient mines—are irregularly scattered over the N. slope of Caradon; but the parent rock is covered with earth and vegetation.

Dunsley Wheal Phœnix, near Shilston's gate,† has been wrought in thick-lamellar, brick-red or pale-brown slate; which is traversed,—at about right-angles to its planes of cleavage,—by veins of disintegrated felspathic granite.

The fissile reddish-brown rubbish brought to the surface at *South Phœnix* ‡ is mixed with masses of a

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* *Table XXVI.*

† Webb & Geach, *History and Progrcss of Mining in the Caradon and Liskeard District*, p. 24, *Pl. I.*

‡ Railways and *(skips)* waggons, which had been adapted to inclined shafts, at *Wheal Friendship* near Tavistock, early in the present century (Leifchild, *Encyclopædia Britannica*, Mining, xv. pp. 225—6. Moissenet, *Annales des Mines*, 6me Série, ii. pp. 251,—5,—7. *Ante*, p. 144, Note.) were adopted at *South Phœnix* long before they were generally used in West Cornwall.

In many British, French, and Belgian collieries the tram-waggons are loaded directly from the seam, and run through the *galleries* at once into well-secured cages, frames, or chairs; which are worked, on guides, through the shafts, at

pearl-white felspathic rock; compact when newly broken, but developing a schistose structure on exposure. Narrow borders of reddish or brownish hue accompany numerous short joints in the fawn-coloured, greenish-grey, and pearl-white slates of *Wheal Jenkin.* And the pellicle of slate which overlies the granite at, and above, the Cheesewring hotel, is of much the same character.

The slate which forms the *(hanging-wall)* upper, or S. side of the *Phœnix lode,* to a depth of thirty-six fathoms, consists mostly of quartz and mica; mingled, however, with small proportions of felspar, and, less

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rates varying from 3·1 to 4·8 fathoms *per second.* The waggons are passed from the pits' mouths to the *dépôts* on tram-ways of the same respective guages as those underground; a single filling and emptying thus sufficing for the entire transit.

Combes, *l'Exploitation des Mines*, III. pp. 262—8, *Pl. XLIV. Fig.* 3—8. Alexander, *Encyclopædia Britannica,* Eighth Edition, VII. p. 126. Smyth, *Coal and Coal-Mining*, pp. 162—8, *Fig.* 26—7.

At *Balleswidden* in the Saint Just district, many of the underground-works were lighted with coal-gas, instead of with candles, during several months of 1856—7. The gas was made at the surface, and carried down one of the shafts, to (the one hundred and ten fathom *level)* a depth of more than one hundred and twenty fathoms, through a two-inch wrought-iron pipe; from which branches, varying from three-quarters of an inch to an inch in diameter, were laid—in some cases for at least one hundred and seventy fathoms—along the several *(levels)* galleries; and similar pipes extended—occasionally as much as ten fathoms above the *levels*—to the various *(backs* or *pitches)* parts in progress. Flexible tubes of *gutta percha* were, on occasion, carried to individuals, but where four men worked together a single jet of gas gave light enough for them all. "In the shaft, *levels*, and *pitches* it answered [so] exceedingly well as to leave no doubt of its serving all the purposes for which it was intended" (NICHOLAS TREDINNICK, WILLIAM CLEMENS, & THOMAS TRAHAIR, Captains of *Balleswidden, Cornish Telegraph,* 20th May, 1857). It was computed that the works were lighted by gas, one-third cheaper than by candles. Owing to personal interests and prejudices of the workmen, however, the experiment was discontinued.

For this statement—compiled from official documents by MR. HENRY THOMAS, Accountant at *Balleswidden,*—the writer is indebted to JOHN JAMES, ESQ., Alderman of Penzance.

frequently, with spiculæ of schorl. It is, mostly, of rather coarse grain, often fissile, and sometimes contorted; here and there it is mottled with crimson or brick-red; but pink, buff, and light-grey are its prevailing hues.

The fine-grained and somewhat thinly-cleaved slates of Knowl and Newland—though occasionally buff-coloured—have often a pinkish tinge.

At and near the surface variegated pearl-white, pale-blue, and reddish-brown slates occupy the *(hanging-wall)* upper, or S., side of the *Sharp Tor lode*; whilst confronting portions of the *(foot-wall)* N. side consist of granite; but, between this and the main body of granite beneath, a considerable thickness of similar slate is interposed.*

(*c*.) Whether the *elvans* which occur in the granite at *West Caradon* and *South Caradon* are mere isolated masses, or form broad *(courses)* bands of great range; † their basis consists principally of translucent quartz and milk-white felspar, with smaller quantities of mica and schorl; in which porphyritic crystals of pinkish-buff or flesh-coloured felspar, and — occasionally truncated — twin crystals of quartz ‡ are frequently embedded.

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* Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 67. *Ante*, p. 659.

† Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 33,—6. *Ante*, p. 660—1.

‡ "In *elvans* which traverse the granite felspar and mica seem to be the prevailing minerals * * * whilst double-pointed crystals of quartz and porphyritic crystals of felspar abound."—Henwood, *Cornwall Geol. Trans*, v. p. 162.

The *elvan-course* which leaves the granite N.E. of Trecarne and returns to it E. of Crow's-nest, but takes its course through slate during the interval,*† comprehends, whilst in granite, much the same ingredients as the *elvans* of *West Caradon* and *South Caradon*, except that the crystals of felspar in its fine-grained basis ‡ are mostly of milk-white hue; in the slate, however, it is so disintegrated that its composition can scarcely be ascertained.

The *elvan-course* which intersects the slates at *Marke Valley* and on the N. flank of Caradon,§ is composed of granular, yellowish-white felspar and quartz, thickly sprinkled with minute crystals of schorl near the sides; but includes large crystals of felspar—pink in some, although milk-white in other, portions—towards the middle.||

(*d.*) The hornblendic formation extends from Saint Cleer E. to *Trethevy* mine; where beds of massive greenish-black hornblende interlie thick-lamellar hornblendic and felspathic slates; ¶ the joints of which are sometimes filled with calcareo-siliceous matter.

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* Whitley, *Geological Map of the Caradon Mining District.*

† *Ante*, p. 661.

‡ "On the south and south-western side of the [granite], some beautiful elvans occur. Near the Trevethey Stone is one of a cream colour marked with light red spots; some again are variegated with black and green spots, producing a beautiful effect. A little above Crow's Nest there is one in the bed of the river more [uniform] in appearance, not unlike common clay earthenware."

GILES, *Cornwall Geol. Trans.*, VII. p. 158.

§ *Ante*, p. 661, *Table XXVI.*

|| Sedgwick, *Cambridge Phil. Trans.*, I. p. 129. Boase, *Cornwall Geol. Trans.*, IV. p. 354; *Primary Geology*, p. 57. Henwood, *Cornwall Geol. Trans.* V. pp. 51, 162; *Ante*, p. 651.

¶ "The hornblende [of Saint Cleer] * * * * * * * * * * is generally

The Cheesewring quarries are wrought in sucessive dome-shaped or slightly conical * bodies, beds,† or sheets of granite; which—differing much in thickness, and declining 5°—10° towards all sides of the hill—conform, in some measure, to its contour.‡

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coarse-grained with shining facets; but as it approaches its termination it becomes more dull and fine-grained, and passes into hornblende-slate, accompanied by hornstone. * * * Hornstone and hornblende-slate passing into clay-slate, are found throughout the whole line of junction, except towards the north-east, where I found no hornstone. In that direction, hornblende-slate, a kind of greenstone-slate, and clay-slate abounding with particles of mica, form the connecting chain of minerals from hornblende to granite. * * * The mineral which I have called hornblende-slate graduates imperceptibly into clay-slate * * * : it appears to be the slaty felspar rock of Jameson, and has been sometimes denominated purple killas.

"I am inclined to think that * * * hornblende is also frequently to be found in other parts of the [neighbourhood] * * *, near Trevethy stone, hornblende and hornstone are found."—Rogers, *Cornwall Geol. Trans*, II. pp. 218—20.

In some of the bowlders of greenstone on St. Cleer down "the hornblende is distinctly crystallized in shining laminæ.

"The hornblende-slate at Rosecradock, is of a blue colour, and very fine-grained; separates into thick rhomboidal laminæ; dips S.E., at about 30°, and contains beds of compact felspar."—Boase, *Ibid*, IV. pp. 208,—10.

An "intermixture of * * * rocks, many of them schistose and ashy [characterises] the argillaceous slates and sandstones from St. Cleer, Liskeard, and Menheniot by Saltash, Plymouth, Yealmpton and Ugborough, to Ashburton and Torbay."—De la Beche, *Report on the Geology of Cornwall, Devon*, &c., p. 79.

"The traps are * * * associated more or less with the slates throughout the series. Those crossing St. Cleer down are excessively hard, and contain a sufficiently large quantity of hornblende to give a highly glistening appearance to the fracture; others have an earthy appearance, and are so completely decomposed that the mass can be removed with a spade.

Giles, *Cornwall Geol. Trans.*, VII. p. 158.

Holl, *Quarterly Journal of the Geological Society*, XXIV. p. 421. *Ante*, p. 661.

* "Wherever an extensive surface of granite is exposed, its layers uniformly exhibit considerable curvatures."—Boase, *Cornwall Geol. Trans.*, IV. p. 366.

† "In the granite near Penryn * * * the Bed-way or Floor is nearly horizontal; * * * the granite splits most easily on this line, * * * so that a workman by attending to this point, constantly gains more wages than others by breaking stones for the roads by measure."

Enys, *London & Edin. Phil. Mag.*, II. pp. 322—3.

‡ "Where the granite is exposed in the Cheesewring quarries, the beds are wrapped around the top of the hill, like the coats of an onion."

Whitley, *Reports of the Royal Institution of Cornwall*, XXXII. p. 31.

The cleavage-planes of the slates which skirt Caradon dip— S.S.E. near Crow's-nest, — E.S.E. on Caradon Down, — S.S.E. at Bodmin-land, — E.N.E. in *Marke Valley*,—N.N.W. from *Phœnix* to *South Phœnix*, and E.—S.E. towards the Cheesewring-hotel.

(*e*) Of the principal joints in the granite,* N. of Crow's-nest, at Gonamena, and near the Cheesewring,

about 0·36 of the whole bear	....	10°—24° W. of N.—E. of S.†
„ 0·23 „	....	35° W. of N.—E. of S. 20° N. of W.—S. of E.
„ 0·41 „	....	E.—W. 23° N. of E.—S. of W.
1·		

* "Taking the present (1839) magnetic north to be about 335° at the Land's End, the [average of] the leading great cleavage * * * differs from it between 13° and 14°. * * * The cross great cleavage is not always sufficiently well characterized to be noticed; * * * it [however] varies more considerably than the north and south cleavage. * * *

"Among the slates of the grauwacke, a direction of 325° is very common, * * * ; on the small scale [however] great divisional planes often cut others at acute angles for short distances, * * * . The crossing of divisional planes, so as frequently to show three series cutting each other, is not confined to the slates of the grauwacke, but is frequently observable in the granites, the arenaceous grauwacke, and the carbonaceous series."—De La Beche, *Report on the Geology of Cornwall and Devon*, &c., pp. 272,—3,—4.

The different directions and comparative frequency of joints observed in the granite and slate of other western mining districts are—

Directions.	Granite.	Slate.
N.—S. 30° W. of N.—E. of S.	0·29	0·34 of the whole.
30° W. of N.—E. of S. 30° N. of W.—S. of E.	0·24	0·23 „
30° N. of W.—S. of E. W.—E.	0·10	0·14 „
W.—E. 30° S. of W.—N. of E.	0·26	0·14 „
30° S. of W.—N. of E. 30° W. of S.—E. of N.	0·07	0·12 „
30° W. of S.—E. of N. S.—N.	0·04	0·03 „
	1·	1·

Henwood, *Cornwall Geol. Trans.*, v. *Table XCIX.*

† In 1840 the magnetic declination was 25° W.
Sabine, *Phil. Trans.*, cxxxix. p. 205, *Pl. XIV.*

(*f*) In the slate of Crow's-nest, Caradon Down, *Marke Valley*, Caradon Coombe, *Phœnix,* and *Wheal Jenkin,*

about 0·60	of the principal joints bear	....	14°—24° W. of N.—E. of S.
,, 0·20	,,	....	40° W. of N.—E. of S. / 20° N. of W.—S. of E.
,, 0·20	,,	....	E.—W. / 40° N. of E.—S. of W.
1·			

other joints, which have different directions,* are of shorter range.

(*e*—1) The *lodes* range between 5° S. of E.—N. of W. and 35° N. of E.—S. of W.,

0·08	of them bearing	5° S. of E.—N. of W.	—	E. & W.,
0·08	,,	E. & W.	—	10° N. of E.—S. of W.,
0·32	,,	....		10°—20° N. of E.—S. of W.,
0·48	,,	....		20°—30° ,, — ,, ,
0·04	,,	....		30°—40° ,, — ,, ,

their mean direction being about 18° N. of E.—S. of W.†

(—2) Notwithstanding both the bedding of the Cheesewring granite‡ and the cleavage-planes of the neighbouring slates § dip *from* the central body of the great granite formation,

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* Haughton. *Phil. Trans.*, CLIV. pp. 405—7.

† "The general bearing of the copper lodes averages about 7 degrees north of west & south of east" [magnetic].—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 5.

The mean direction of the *lodes*	in the	Helston district	is	16°	N. of E.	—	S. of W.,
,,	,,	Camborne	,,	20°	,,	—	,, ,
,,	,,	Redruth	,,	22°	,,	—	,, ,
,,	,,	St. Agnes	,,	22°	,,	—	,, ,
,,	,,	St. Austell	,,	13°	,,	—	,, ,
,,	,,	Callington & Tavistock	,,	9°	,,	—	,, .

Henwood, *Cornwall Geol. Trans.*, v. p. 250, *Table CIII.*

‡ *Ante*, p. 672.

§ *Ibid*, p. 673.

only 0·04 of the *lodes* severally described (in *Tables XXIII.—XXVI.*)	dip *from* *		the granitic mass;
whilst 0·96 „ „	„ *towards* *		

meanwhile the bedding of one rock dips 5°—10°,† and the cleavage of the other 12°—20°; ‡ the (opposite) inclination of the *lodes* averaging 69°—70°. §

(—3) The *lodes* which traverse dissimilar rocks differ—here as elsewhere ||—in width; thus—

those partially or wholly in slate—although too few to offer noteworthy results	range from	1 foot to	10 feet	& average	6·8 feet	in width;	
whilst the *lodes* peculiar to the granite	„	1 „	12 „	„	2·0 „	„	;
the mean width, throughout the district, being about					3·2 „ ¶	„	.

(—4) The *lodes*—comprehending every ingredient of the rocks they traverse, although differently aggregated and in different proportions,—consist chiefly of quartz, chlorite, and felspar; associated, at intervals, with smaller proportions of mica and schorl. Sometimes the three principal of these constituents, but perhaps more frequently two of them indifferently, are intimately mixed; and, occasionally, this incorporation is veined or sprinkled with the same substances

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* "Of 296 examples, 162 [0·55] dip towards, and 111 [0·37] from the nearest granite, whilst there are 23 [0·08] doubtful cases."

HENWOOD, *Cornwall Geol. Trans.*, v. p. 245.

† *Ante*, p. 672.

‡ *Tables XXV.—XXVI.*

§ "Throughout Cornwall and the west of Devon, the mean dip of the *lodes* may be about 70° from the horizon."

HENWOOD, *Cornwall Geol. Trans.* v. p. 247.

|| "On the whole the *lodes* which occur in the granite are smaller than those in the slate."—*Ibid*, p. 241.

¶ The average width of the *lodes* in the Saint Just, Saint Ives, Marazion, Gwinear, Helston, Camborne, Redruth, Saint Ives, Saint Austell, Callington, and Tavistock districts is about 3·61 feet."—*Ibid, Table CI.*

in different degrees, with either of them separately, or —in the S. of the district—with fluor.*

As well N. as S. of Caradon the shallower parts of the *lodes* contain, at times, considerable quantities of earthy brown iron-ore; but it, and the minerals which accompany it, are not of precisely the same character on opposite sides * of the granite.

(—4[1]) *Stowes*,† *Phœnix*,‡ *South Phœnix*,§ *Dunsley Phœnix*, § and *Marke Valley* ||—wrought in the granite or in the slate adjoining it,—afford iron-ore of dark-brown — occasionally, indeed, of blackish — hue, scattered through hard, massive, though frequently cavernous, quartz, and mixed — downward especially — with chlorite.¶ In a matrix of this character, these (N.) *lodes* have—perhaps for ages**

* "Fluor-spar, found plentifully in most of the southern lodes, has never been seen at the Phœnix Mines."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 28.

† *Ibid*, pp. 28—30. Allen, *History of Liskeard*, p. 395.

‡ *Ante*, pp. 657,—69, *Table XXV*.

§ *Ibid*, p. 668.

|| *Ibid*, pp. 659,—67,—71, *Table XXVI.*

¶ "At the Stow's Mine West, the lode contained towards the surface immense masses of highly ferruginous gossan, becoming, however, as it approached Clanacombe Mine [E.], less impregnated with iron * * * . In depth the matrix is generally composed of blue capel, carrying a leader of quartz and iron * * * . There is a little chlorite."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 30.

"A Scovan lode, is found of hard compact crystalline Stone, either of a brown or black hue, according to the colour of the Tin with which it is mixed. * * * Sometimes the Scovan tin lies in a less solid Lode, which is cavernous and full of holes, thence called a Sucked Stone by the Tinners."

Pryce, *Mineralogia Cornubiensis*, p. 90.

Henwood, *Cornwall Geol. Trans.*, v. pp. 226—8.

** "*North Phœnix* * * * was worked by the old men about 150 years ago for tin."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 57.

yielded an abundance of tin-ore.* Softer and lighter-coloured varieties of iron-ore, mixed with granular quartz, are impregnated with earthy black copper-ore, the red oxide of copper, malachite, Tamarite, chrysocolla, vitreous copper, and tile ore.†

(—4²) At *Marke Valley* ‡ the *lodes*—as they traverse the slate—cease to yield earthy iron-ore within short distances of the surface, and thenceforth consist of quartz, chlorite, and felspar, mixed in various parts with different proportions of iron-pyrites, copper-pyrites, and tin-ore; sparingly, and at wide intervals, sprinkled with minute nests of earthy black copper-ore. A mere congeries of small veins represents the *Sarum lode* on the confines of the *elvan*-course; but within it they reunite, and the *lode* assumes, at least, its previous width.

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* "The [Stow's] lode—backed up to the surface—was laid open by the old men for about a mile in length in their efforts to discover and raise tin, large quantities of which they returned."—WEBB & GEACH, *History and Progress of Mining in the Caradon and Liskeard District*, p. 28.

"The first [steam]-engine in the Liskeard district was [erected] at Stowes; but the mine was stopped and the materials were stolen about 1825."

ALLEN, *History of Liskeard*, p. 427.

"About 1836 * * * considerable quantities of low-priced tin ore were raised from the Stow's Mine. * * * About [1842] the Wheal Jenkin lode afforded, above the adit, large quantities of low-priced tin-stuff."—WEBB & GEACH, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 28—66.

As late as 1851 the remains of at least a dozen stamping-mills were yet visible in various parts of Caradon-coombe, between Shilston's-gate and *Marke Valley*; in 1867, however, most of them had disappeared.

† *Ante, Tables XXV., XXVI.*

‡ "Marke Valley was sunk * * * to the 26 [fathom-level], and about 1838 a small quantity of copper-ore was returned."—WEBB & GEACH, *History and Progress of Mining in the Caradon and Liskeard District*, p. 25.

Allen, *History of Liskeard*, p. 421. *Ante*, pp. 659,—67,—71, *Table XXVI.*

At *Phœnix*,*—in the granite,—on the contrary, the *lode* is still charged with earthy iron-ore, as well as with native copper, earthy black copper-ore, malachite, vitreous copper, copper-pyrites, and tin-ore, to the very bottom of the mine.

(—4[1]) The outcrops *(backs)* of the more numerous, but narrower, *lodes*, opened in the S. slope of the granite at *West Caradon*† and *South Caradon*,‡ consist of soft, pale — and occasionally reddish-brown iron-ore,§ granular and friable quartz, granitic matter, chlorite in small quantities, and fluor at intervals. Where a cellular structure prevails nests of felspar-clay, earthy black copper-ore, and malachite are not uncommon; elsewhere the same vein-stones enclose

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* *Ante*, pp. 657,—69, *Table XXV.*

† *Ibid*, pp. 661,—70,—1, *Table XXIII.*

‡ *Ibid*, pp. 661,—70,—1, *Table XXIV.*

§ "The discovery of *gossan* (or oxide of iron) very near the surface, in places where the ground was broken, on and near the Caradon hill, prompted the driving of several levels into the sides of this and adjacent elevations. They were relinquished, however, by one party after another without success."

Allen, *History of Liskeard*, p. 396.

Phillips (W.), *Geol. Trans.*, ii. pp. 117,—26. Carne, *Cornwall Geol. Trans.*, ii. p. 122. Fox, *Reports of the Royal Cornwall Polytechnic Society*, iv. p. 85. Ansted, *Quarterly Journal of the Geol. Society*, xii. p. 149; xiii. pp. 245,—49,—51.

"The Tender Red Gossan is very much inclined to produce Copper-ore, especially if the Gossan be spungy, cellular, and of a very red colour, like to a well-burnt brick. When it is thus, and spotted, or tinctured with green Copper-ore, like pieces of Verdigrease, it does not often deceive the proprietors. So, likewise, Stones of blue or black Copper-ore, or of yellow ore having a black or purple outside, are very hopeful to follow when mixed with this Gossan."

Pryce, *Mineralogia Cornubiensis*, p. 88.

"The *lodes* which yield copper-ore in granite almost always contain *gossan* near the surface, and it usually continues to somewhat greater depths than it does in slate."—Henwood, *Cornwall Geol. Trans*, v. p. 227.

also small shapeless *bunches* of vitreous copper, copper-pyrites,* iron-pyrites, and mispickel; and masses of native metal, encrusted with crystals of ruby-copper, and invested with earthy black copper-ore, are of casual, but less frequent, occurrence.

(-4^2) In the deeper parts of both mines quartz, felspar, chlorite, and occasional masses of granite, are still the chief ingredients; but earthy brown iron-ore —although yet observable here and there—is less plentiful than it had previously been, whilst fluor—on the contrary—is much more abundant. The proportions of vitreous copper, earthy black copper-ore, and malachite decline at the same time; and ruby copper as well as the native metal—still dwindling as the depths increase—at length disappear; in copper-pyrites, however,—as in fluor—the deepest parts of the *lodes* are the richest. Whether at smaller or greater depths these (S.) *lodes* give little or no tin-ore.

It appears, therefore, that the *lodes* of *Stowes, Phœnix, South Phœnix, Dunsley Phœnix*, and *Marke*

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* "Dark grey crystals of copper-glance are often deposited on low six-sided prisms, which, in respect to form entirely agree with that species. Their surface, however, is never perfectly smooth. On breaking them they do not present a uniform appearance; generally the portions nearest the surface consist of the reddish metallic substance of variegated copper, whilst the rest possess the grey colour and conchoidal fracture of copper-glance. * * * On breaking the six-sided prisms here alluded to, I found a stratum of copper pyrites contiguous to the surface, whilst the rest consisted of variegated copper. * * * The specimen [was] covered with black pulverulent oxide, but the surface of another was perfectly bright. * * * These changes can be explained upon the supposition that the copper contained in the original species has been replaced by iron, in a smaller quantity however, as every particle of iron required twice the quantity of sulphur to be converted into protosulphuret in the variegated copper, and four times the quantity for that portion of it in the state of copper pyrites."

HAIDINGER, *Edinburgh Journal of Science*, VII. pp. 131—2. (Abridged.)

Valley (N. of the Caradon granite*) have afforded—beside copper and several of its ores,—large quantities of tin-ore,* but contain no fluor: † whilst the *lodes* of *West Caradon* ‡ and *South Caradon* § (S. of the Caradon granite) have yielded copper, copper-ore, and fluor in very great abundance; || but, notwithstanding the immediate vicinity of stanniferous granite at *Gonamina* ¶—they give little or no tin-ore.**

(—5) The joints of one well-developed series †† have the same directions as many of the *lodes*,‡‡ and often traverse them lengthwise; not uncommonly, indeed, the same *lode* is thus divided, by several such undulating joints into several subordinate veins, *combs*, or slices, of unequal thickness. §§ This structure,

* *Ante*, p. 676.

† Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 28. *Ante*, p. 676, Note *; pp. 676—7.

‡ *Ibid*, p. 678, Note †.

§ *Ibid*, Note ‡.

|| *Ibid*, pp. 678—9.

¶ *Ibid*, pp. 664—5.

** "Ainsi tous les amas stannifères connus sont caractérisés par la présence du fluor: la proportion de cette substance est souvent considerable, se on la compare, non au volume total de l'amas, mais à la quantité d'étain qui se trouve dans ces gîtes."—Daubrée, *Annales des Mines*, 3me Série, xx. p. 101; *Ibid*, 4me Série, xvi. pp. 130—7.

†† *Ante*, p. 673.

‡‡ *Ibid*, p. 674.

§§ Pryce, *Mineralogia Cornubiensis*, p. 95. Werner, *New Theory of the Formation of Veins*, pp. 83,—7. Phillips, (W.) *Geol. Trans.*, ii. p. 138. Thomas, *Report on the Mining District from Chasewater to Camborne*, pp. 19—20. Carne, *Cornwall Geol. Trans.*, ii. p. 120. Fox, *Report of the Royal Cornwall Polytechnic Society*, iv. pp. 85,—9. De la Beche, *Report on the Geology of Cornwall and Devon*, &c., pp. 339—45. Henwood, *Cornwall Geol. Trans.*, v. p. 232; *Ante*, pp. 418,—33, 648.

however, seldom extends beyond limited portions of the *lodes;* for—as in the rocks—after comparatively short ranges, the joints gradually disappear. Sometimes each subordinate or constituent vein is characterized by certain peculiarities of composition or arrangement; still, every *lode* has—so to speak—a distinctive physiognomy of its own.*

Many—but especially the shallower and the poorer†—parts of most *lodes* abound in *(vughs)* cavities lined with crystals of quartz, which are often encrusted with ruby copper and virgin metal, where the *Country* is granitic; but more frequently with iron-pyrites and copper-pyrites when it is of schistose structure.

(*f*—1) The *cross-courses*—maintaining much the same direction as one well-pronounced series of joints‡—range from 6° E. of N.—W. of S. to 24° W. of N.—E. of S.; and, on an average, bear 13° W. of N.—E. of S.§

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 208; *Ante*, p. 89.

† Henwood, *Edin. New Phil. Journal*, XXII. pp. 157,—271, *Annals of Electricity*, I. p. 125; *Annales des Mines*, XI. p. 587; *Cornwall Geol. Trans.*, v. p. 195.

‡ *Ante*, p. 673.

§

The mean direction of the *cross-veins*	in the	Saint Just district	is	20° N. of E.—S. of W.,
,,	,,	Saint Ives	,,	38° S. of E.—N. of W.,
,,	,,	Marazion	,,	41° S. of E.—N. of W.,
,,	,,	Gwinear	,,	43° W. of N.—E. of S.,
,,	,,	Helston	,,	21° S. of E.—N. of W.,
,,	,,	Camborne	,,	34° W. of N.—E. of S.,
,,	,,	Redruth	,,	35° S. of E.—N. of W.,
,,	,,	Saint Agnes	,,	39° W. of N.—E. of S.,
,,	,,	Saint Austell	,,	21° S. of E.—N. of W.,
,,	,,	Callington & Tavistock	,,	43° S. of E.—N. of W.,
the average of the whole being		....		38° S. of E.—N. of W.

HENWOOD, *Cornwall Geol. Trans.*, v. p. 279.

(—2) The *cross-courses*—more highly inclined than the *lodes*,* dip, on an average, just 80° from the horizon; and—like the *lodes* on both sides †—underlie towards the great body of granite.‡

(—3) The *cross-courses*, which are rather broader than the *lodes*,§—as well in this neighbourhood as in other mining districts of the W.||—vary from 24 feet to 0·6 foot, and average 4·6 feet in width.

(—4) The *cross-courses*–partaking, in some measure, the nature of the formations they traverse—consist of granitic matter when in granite,¶ and of *elvan* when in *elvan;* but—differing in this respect from the *lodes*, which contain larger proportions of quartz**— they are usually more felspathic than the *(Country)* rocks. Moreover, in the positions of the crystals of felspar they include, there seems an occasional approach to

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* "To whatever point the *cross-courses* may incline the amount of their inclination is, on the whole, considerably greater than that of the *lodes*, and, on an average, is probably little, if at all less, than 80°."

Henwood, *Cornwall Geol. Trans.*, v. p. 277.

Ante, pp. 408, 526—7.

† *Ibid*, p. 675.

‡ "In 165 examples, 75 (0·46) dip towards, } the granite,
61 (0·37) „ from, }
and there are ...... 29 (0·17) doubtful cases."

Henwood, *Cornwall Geol. Trans.* v. p. 277.

§ *Ante*, p. 675.

|| In the districts of Saint Just, Saint Ives, Marazion, Gwinear, Helston, Camborne, Redruth, Saint Agnes, Saint Austell, Callington and Tavistock the *cross-courses* range from 0·8 foot to 19 feet, and average 4·03 feet in width.

Henwood, *Cornwall Geol. Trans.*, v. *Table CIV.*

¶ "In the granitic tracts many of the *cross-veins* consist almost entirely of granitic matter; this is commonly in a state of disintegration, and often contains much more felspar, and occasionally more mica also, than the contiguous rocks."—*Ibid*, p. 262.

** *Ante*, p. 675.

uniformity.* They—like the *lodes*—occasionally enclose masses *(horses)* of the rocks.

(—5) Every *cross-course* is traversed by numerous longitudinal joints,† of which the flexures and consequent intersections divide it into lenticular masses and subordinate veins of unequal widths.‡ Such joints mostly present glossy faces of clay; which, even within short distances, are often marked with unconformable striæ, and on the opposite sides of the selfsame masses and veins are, sometimes, thus scored in contrary directions.§

In all parts of this district the *cross-courses* have a W.,|| and the *lodes*—with but one exception—a N.,¶ dip.

All (displacements) *heaves*, at the intersections of the *lodes* by

the first** and third†† *cross-courses* (counting from the W.), are—save in a single instance .... } towards the (R.) right-hand;‡‡

* Henwood, *Cornwall Geol. Trans.*, v. p. 262.

† *Ante*, p. 680.

‡ "One of the most remarkable features in the structure of *cross-veins* is the prevalence of joints; varying, however, in direction and dip, but preserving certain limits; so that, whilst they intersect each other, their curvatures seem projected on the same lines, which are in fact the directions of the *cross-veins*."
HENWOOD, *Cornwall Geol. Trans.*, v. p. 260.
Ante, pp. 13, *Fig.* 2; 648.

§ "On the eastern side of Tregoning-hill the faces of the joints in the granite are irregularly striated, like those of *slickensides* on the *walls* of many *lodes*."
HENWOOD, *Cornwall Geol. Trans.*, v. pp. 53, 172,—81—2.
Ante, pp. 13, 469, 552—3, 654,—64.

|| *Ibid*, p. 682.

¶ *Ibid*, p. 675.

** The *cross-course* in *West Caradon, Table XXIII.*

†† The *Little W. cross-course* in *South Caradon, Table XXIV.*

‡‡ Pryce, *Mineralogia Cornubiensis*, pp. 98—9. Thomas, *Survey of the Mining District between Chasewater and Camborne*, p. 22. *Ante*, p. 183, Note †.

those at intersections by

the second* and fourth,† are—on the contrary—always............ } towards the (L.) left-hand ; ‡

every (displacement) *heave*, however, is ,, side of the (G.A.) greater angle.§

But intersections are not in all cases accompanied by (displacements) *heaves*, for in 33 instances

3 (or 0·11 of them) the *cross-courses* simply cut through, without } *heaving* the *lodes*; §

14 (,, 0·41 ,,) the *heaves* were towards the (R.) right-hand; § and

16 (,, 0·48 ,,) ,, ,, (L.) left- ,, .§

The average extent of the *heaves* is .... about 13·0 feet; ‖

,, those towards the (R.) right-hand are ,, 11·1 ,, ; ‖

,, ,, (L.) left- ,, ,, 13·7 ,, . ‖

The *cross-courses*—as already mentioned—

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* The *Great cross-course* in *South Caradon, Table XXIV*.

† The *Middle cross-course* ,, , ,, .

‡ *Ante*, p. 683, Note ‡‡.

§ The following columns show the results of the intersections of *lodes* by *cross-courses* in the W. districts generally :—

Metalliferous character of *lodes*.	Heaves. Simple intersections	Right-hand (R.)	Left-hand (L.)	Greater-angle (G.A.)	Smaller angle (S.A.)
Copper *lodes*	0·177	0·524	0·298	0·742	0·088
Lodes yielding both copper & tin ores ..	0·372	0·440	0·186	0·560	0·068
Tin *lodes*	0·180	0·560	0·260	0·520	0·300
Means	0·227	0·511	0·262	0·635	0·129

Henwood, *Cornwall Geol. Trans*, v. pp. 286—7 ; *Ante*, pp. 128—9.

‖ In the other W. districts

the mean distance of the *heaves* of all the *lodes* is .... 16·4 feet;

, ,, towards the *right-hand* .... 18·7 ,, ;

,, ,, ,, *left-* ,, ... 12·0 ,, ;

,, , ,, *greater angle* .... 16·3 ,, ;

,, ,, ,, *smaller* ,, ... 17·1 ,, .

Ibid, p. 287.

	feet		feet
maintain, on, the whole, a mean width of	4·6,*‡	and the *heaves* they occasion average	13 0; †‡
those of them, however, which exceed the mean, preserve (amongst themselves) ,,	10·6,‡	,,	20·1; ‡
whilst such as fall short of the mean, measure *(inter se)* .... ,,	2·7,‡	,,	10·1.‡

The widths of the *cross-courses*, and the extent of the *heaves* which attend them, at different depths,§ are shown in the following columns;—

Depths. fms.	*Cross-courses.* Widths,—feet.	*Heaves.* Extent,—feet.
Surface to 80......	5·4	13·8
80 ,, 100......	4·1	12·0

(*g*—1) The *Great Spar-course* which, in *South Caradon*, bears 20°—24° W. of N.—E, of S., is nearly perpendicular, measures between two and three feet in width, and consists of quartz mixed, occasionally, with earthy red iron-ore, intersects, but does not (displace) *heave* the *Great cross-course.*‖

* *Ante*, p. 682.

† *Ibid*, p. 684.

‡ The average distance of the *heaves* by *cross-veins*
less than 1 foot wide, is .... 12·5 feet;
more than 1 foot wide, ,, ... 23·0 ,, .
Henwood, *Cornwall Geol. Trans.*, v. p. 298.

§ Throughout the other W. districts
the mean distance of the *heaves* of *lodes* is .... 16·4 feet;
at less than 100 fathoms deep they are *heaved* .... 15·3 ,, ;
,, more ,, 100 fathoms ,, ,, ... 17·2 ,, .
The mean breadth of the *cross-veins* at less than 100 fathoms deep is 3·9 ,, ;
,, ,, more than 100 ,, ,, 4·4 ,, .
Ibid, p. 306.

‖ "At *Polladras Downs* the eastern (vein of clay) *flucan* intersects the quartzose *cross-course*, but occasions no (displacement) *heave*."
Ibid, p. 295, *Table XLV**.

No *slide* has been observed in the district.*

Notwithstanding the extent of early tin-mining† in the district,—that the springs which have supplied water for household use now yield considerable precipitates of copper,‡—and that copper-mines had been so long,§ so largely, and so profitably wrought, as

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* "The *slides,* hitherto observed * * * intersect only the schistose rocks and the *elvans,* and other veins traversing them; whilst there is not a single well-marked instance of a *slide* in the granite, or the massive rocks of the slate formation, yet known in any part of Cornwall."

Henwood, *Cornwall Geol. Trans.,* v. p. 282.

† *Ante,* pp. 676—7.

‡ "The water which now gives a remunerative precipitate of copper, was formerly drank by the people of Crow's-nest. * * *. The iron-work of the pump which supplies my house, is covered with precipitated copper."

John Taylor, Esq., Purser of *Craddock Moor,* MSS. *Ante,* pp. 585,—92.

§ The following statements, of writers on early copper-mining in Cornwall, can scarcely be read without interest.

(1) "Copper is found in sundrie places, but with what gaine to the searchers, I have not been curious to enquire, nor they hastie to reueale. For at one Mine (of which I tooke view) the Owre was shipped to bee refined in Wales, either to saue cost in the fewell, or to conceale the profit."

Carew, *Svrvey of Cornwall* (1602), p. 6.

(2) In Kea " the waste land of [Blanchland] is not only abounding in tin and tin mines, but for about twenty years last past hath yielded its owner about twenty thousand pounds out of its copper mines, though the * * * land in which it is found, is in many places scarce worth eighteenpence per acre."

Hals, *Parochial History of Cornwall* (1685—1736, Edited by Davies Gilbert, D.C.L., P.R.S.), ii. p. 300.

(3) "Within these sixty years, Copper has turned to very great account in this county; and there have been very great discoveries made therein, both in the eastern and western parts of it, which have produced most of the varieties of ore found in Sweden, Germany, Hungary, and elsewhere: such as Yellow (which is the most plentiful and common of any), Green, Blue, Black, Ash-colour, and Solid ore. * * * This variety of ores, and great increase of the mines, has occasioned the setting up of six several companies for buying of the ore."—Tonkin, *Parochial History* (1702—33). Carew, *Survey of Cornwall,* Edited by Lord De Dunstanville, p. 21.

(—*a*) "In [Kea] parish lies the extensive manor of [Blanchand] * * * which within these fifty years brought [the family of Boscawen] more money for copper than almost all the other mines in the county together, if the last fifty

well on both sides of the Tamar, as in many parts

years are excepted, during which time great discoveries have been made in various other places."

TONKIN, *Parochial History* (1702—33, Edited by DAVIES GILBERT, D.C.L., P.R.S.), II. p. 302.

(4) "Being sollicited, about twenty years since, to make a collection of Cornish fossils, for Dr. Boerhave, Dr. J. F. Gronovius, Dr. Linnæus, and the late Dr. Isaack Lawson, then at Leyden, and finding the natural products of this County much commended; and being also frequently employed afterwards in the same office, I became more and more fond of collecting, till my specimens tempted me more narrowly to inspect and describe them. * * *

"That ore [of copper] which is most common is of a yellow brass-colour; * * * and, according to the quantity of the barren stone intermixed, sells from five to fifteen pounds *per* ton * * *.

"Of the green coppers, some are as light as a feather, being mere *ærugo*, or verdigris, some more solid and stony * * *. There is also a flaky kind of close contexture, sometimes cohering in tubes as it drops * * *.

"I have likewise a blue earth of an extremely fine and small grit * * *.

"The grey ore is often prettily spotted with yellow and purple, but the more of this mixture the less is its value. When it is of an uniform lead colour throughout it is richest, and contains a great deal more metal than the yellow or green, being worth between fifty and sixty pounds *per* ton.

"Copper appears sometimes as a blue-black earth * * *.

"The red-ore mixed with glassy speckles (the crystallized salts of this metal) is called the fire-ore * * *.

"The most perfect copper, from which the before-mentioned are only so many inferiour and different removes, is the Malleable (from its purity called in Cornwall the Virgin-ore) which, in small quantities at least, is found in all the most considerable copper-mines.

A "hopeful discovery" in the Pool-mine was at twelve fathoms from the surface near the "*black-ore shaft*."

"About sixty years since, some gentlemen of Bristol made it their business to inspect our mines more narrowly, and bought the copper raised at N'uun-vian in Piranuthno, and at Mr. Ustick's works in St. Just for two pounds and ten shillings *per* ton, and scarce ever more than four pounds *per* ton. It must be observed that the yellow ore, which now sells for between ten and twenty pounds *per* ton, was at this time called *poder* (that is, dust) and thrown away as mundic. [Their] gains * * * encouraged other gentlemen, about forty years since, not only to buy copper at a low rate, but to engage as adventurers in some old mines; and at this time Mr. John Costar, a gentleman well skilled in metals, and particularly knowing in mechanics and hydraulics, undertook * * * to drain some considerable mines: he taught the people of Cornwall also a better way of assaying and dressing the ore. Here we may date the advance of the price of copper and improvement of copper-mines * * *.

of Western Cornwall; it was not until 1835—40,

"The first and greatest copper-mines which have turned out considerable profits within these forty years, are—Chace-water, in the parish of Kenwyn; North Downs, in Reddruth; Huel-rôs, in St. Agnes; Dalcooth, Bullen-garden, Entral, Longclose, Roskaer, and Huel-kitty, in Camborne; Huel Fortune, in Ludgvan; the Pool, in Illogan; Metal-works [United Mines] and Trejuvian, in Gwenap; Binner Downs and Clowance Downs, in Crowan; Huel-cock and Rosmoran, in St. Just; and Herland mine in Gwinear. But the greatest and most sudden gain * * * was that of Huel-virgin, in Gwenap, in July and August, 1757. In the first fortnight's working, it threw up copper sold for five thousand seven hundred pounds; in the next three weeks and two days, as much copper as sold for nine thousand six hundred pounds: to raise the first-mentioned quantity, it cost the adventurers no more than one hundred pounds [less than four pence farthing in the Pound]; to raise the second, a trifle more in proportion to the quantity * * *. The Lords dues are generally one-fifth part of the whole produce clear of all expence, never less than one-eighth clear * * *."
Borlase, *Natural History of Cornwall*, pp. 168—9, 197—8, 205—6; *Pl. XVIII, Fig* 1.

(—*a*) "About [1750] one Mr. Swaine built a furnace or two [near] the great Copper works in Camborne about half a mile north of the Churchtown in order to run the poorest copper ore (value 5 shillings p^r ton) into a Regulus, aiming at nothing farther: for this purpose he brought all his Pitcoal on horseback from Heyl cellars near seven miles off * * *. This humble plan [was] pursued with success for some years."

Borlase, *Natural History of Cornwall* (Emendations and additions by the Author, in preparation for a Second Edition. From a copy in the possession of Frederick Martin Williams, Esq., M.P., F.G.S., of Goonvrea). *Journal of the Royal Institution of Cornwall*, I. (1865), Supplement, p. 32.

(5) "Though the richness of our Copper works is not a late discovery, yet it is not a hundred years that the knowledge of working them to good effect hath been understood * * *.

"Native copper is frequently found in our mines, near the surface, or commonly but a few fathoms deep * * *.

"Wherever Copper is found, there is always green or blue Vitriol * * *.

"The Stalactitical, is generally of a brassy colour; and so is the blistered buttony Ore * * *. Filagree, Laced, Machacada Copper, is the precipitation of Copper on the laminæ of Gossan * * *.

"Green Copper Ore is very rare in Cornwall. Blue Copper is seldom met with.

"Gray Copper Ore is one of the richest sorts in this county; and will produce the greatest quantity of Metal, of any Copper Ore. Gray Ores are generally the heaviest of all; * * * they must be dressed by sorting and sizing them, &c.

"Black Copper Ore, of a bluish-black, is also very rich. This is either solid or sandy * * *. It is so light, that it will not bear the usual dressing by water;

that copper was successfully worked on both the

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but is generally griddled out and put to the pile for sale, as it rises from the Mine. Being in this condition, it partakes of Mundick, Gossan, Earth, and Crystal, so largely, that the intrinsick value of the Ore will be carried off with it. It is said, that formerly several thousand pounds worth of this Ore was thus washed into the rivers, and discharged into the sea from the old Pool Mine. This kind of Ore in the Lode is oftentimes so fair, that it may be raised and dressed fit for smelting at the rate of a shilling out of the pound, in the price it sells for; nay * * * many score tons [were] raised out of North Downs Mine at tenpence. This Ore generally lies shallow; and seventy years ago, when copper was not searched for and little known amongst us, the Tinners threw it into the rivers as refuse, by the name of Poder,[a] which signifies dust, Mundic, or waste. After it became well known, and was wrought for sale, it seldom exceeded £3 : 10*s.* : 0*d.* per ton for several years, while there were but one or two purchasers.

"Of yellow Copper Ore I have observed four sorts. The first is found shallow among black Ore, * * * and it can be scraped into yellow dust of a rich appearance. The second is fine gold coloured flakey Ore, * * * [worth] from £12 to £15 per ton * * *. The third is a perfect brass coloured Ore, and is reckoned the best colour of any for its continuance in the Mine: * * * although the value may be not more than from £7 to £10 per ton * * *. The fourth and deeper Copper Ore is of a pale yellow, pretty much corrupted with Mundick, and of an inferior price, being from £4 to £6 per ton. * * *

"Even burnt leavings of Tin are often considerably valuable, especially if they are cupreous; and even the poorest bring ten or twenty shillings per ton. All burnt leavings, till the year 1735, were esteemed good for nothing. But in that year Mr. Morgan Bevan an old experienced assayer [having] assayed a sample of three tons found, to his surprise, that he could give seven pounds four shillings and sixpence per ton for them; and presently after he bought several parcels more of the principal Tin dressers. From that time burnt

a "The refuse and leavings from the stamping-mills, &c., which are carried by the streams down to lower grounds, and after some years lying, necessary to consume the mixture of bad metal, and *poder* (as they call it), viz. mundick, copper, &c. yield very good profit to the adventurers."—Tonkin, *Parochial History* (Carew, *Survey of Cornwall*, Edited by Lord De Dunstanville), p. 28.

"In dressing of leavings of tin * * * the slime being compounded of the lighter parts of the ore intimately mixed a greater quantity of earth and stones, bruised to dust by the mill, is * * * [set] on one side until the water leaks away and leaves it to dry exposed to the sun and air [which act as menstrua], consuming, or rather dissolving the *Poder*, that is the Mundick, particles of Copper, and other trash. Then it is digged and broken to pieces * * * when it is trunked and framed * * * ."—Pryce, *Mineralogia Cornubiensis*, p. 226.

"The sprinklings of copper which frequently occurred in the tin mines were considered as a species of yellow marcasite, or mundic, and was called *Poder* * * *. The interest of those who first discovered this mineral * * * to be copper-ore, made it for some time to be kept a profound secret, so that the precise time [of the discovery] is not ascertained; but it is believed to have been about the beginning of the last century."

Michell, *Manual of Mineralogy*, p. 40.

northern and southern slopes of Caradon. Since that

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leavings, impregnated with copper, were taken much care of * * *. When the Brass-wire Company carried on the great Tin Mine of Chacewater, before this discovery they cast away some hundred tons of burnt leavings, to their great prejudice; but since that time there have been large quantities sold from the same mine. * * *

"About fifty years back great quantities of Copper Ore were risen from Huel Fortune in Ludgvan, Roskear in Camborne and Pool Adit in Illugan; the produce of which Mines were sold to the few buyers at their own price, * * * till they were interrupted by a gentleman from Wales * * *, who bought at the advanced price of six pounds and five shillings per ton, fourteen hundred tons of Copper Ore, which had been lying unsold for some years at Roskear and Huel-Kitty, and for which the confederated buyers would give only four pounds and five shillings * * *. This new comer bought nine hundred tons more at Roskear at seven pounds per ton; and in six months * * * he purchased three thousand tons."—Pryce, *Mineralogia Cornubiensis,* pp. 61—3, 192, 226, —30,—7,—86—7. (Abridged.)

(6) "A century ago amongst the miners of Cornwall, whatever was not tin was heedlessly thrown aside; and within that period, on the discovery of copper beneath the tin, it was no uncommon observation that the 'ore came in and spoilt it.' It is an undoubted fact that many roads in the county were mended with copper ore."—Phillips (W.), *Geol. Trans.* (1814), ii. p. 141.

(7) "At the commencement of the last century, when yellow ore or pyrites had been long appreciated, the far more valuable redruthite, or sulphide of copper was thrown as worthless rubbish over the cliffs of St. Just into the Atlantic."
Smyth, *Introductory Lecture to the course of Mineralogy and Mining, at the Museum of Practical Geology* (1852), p. 10.

Although other writers have treated of this subject, their statements differ so slightly from those already given, that it seems unnecessary to quote them."

The following particulars—collected from many books and extracted from several Registers—supply some means of judging, whether the principal writers on early copper-mining in Cornwall, were eye-witnesses of the matters they have described, or have founded their statements on other evidence.

Richard Carew, Esq., was born at Antony in 1555, and died there in 1620.
His "*Survey of Cornwall*" was published in 1602, but appears to have been in private circulation previously.

William Hals, Esq., was born at Tresawsen in Merther, in 1653, and died at Saint Wenn in 1737.
His "*Collections for a Parochial History of Cornwall*" were commenced about 1685 and brought down to 1736.

Thomas Tonkin, Esq., M.P., was born at Trevaunance, St. Agnes, in 1678, and died at Pol Gorran, Gorran, in 1742.
His "*Notes, illustrative of the History and Antiquities of Cornwall,*" were commenced in 1702 and continued till 1742.

time, however, many mines have been opened there

The Reverend William Borlase, LL.D., F.R.S., was born at Pendeen, St. Just., in 1695, and died at Ludgvan in 1772.

In 1722 he was instituted to the Rectory of Ludgvan, and in 1732 he was presented to the Vicarage of St. Just. His "*Natural History of Cornwall*" was published in 1758.

[The Mining Academy of Chemnitz, in Lower Hungary, was established in 1760; that of Freiberg, in Saxony, was opened in 1767.]

William Pryce, Esq., M.D., was born about 1720—30, and died at Redruth in 1790.

His "*Mineralogia Cornubiensis*"—commenced about 1751-5—was published in 1778.

William Phillips, Esq., F.L.S., F.G.S., was born in London in 1773, and died there in 1828.

His Memoir "*On the Veins of Cornwall,*"—commenced in 1800—was published (*Geol. Trans.*, II.) in 1814.

John Taylor, Esq., F.R.S., F.G.S., was born at Norwich in 1779, and died in London in 1863.

His article on Mining was published in Rees's Cyclopædia, XXIII. (1819).

John Michell, Esq., was born at Calenick, Kenwyn, in 1773, and died there in 1868.

His "*Manual of Mineralogy*" was published at Truro in 1825.

Sir Henry Thomas De la Beche, C.B., F.R.S., F.G.S., Director of the Ordnance Geological Survey, was born in London in 1796, and died there in 1855.

His "*Report on the Geology of Cornwall, Devon, and West Somerset*" was published in 1839.

Warington Wilkinson Smyth, Esq., M.A., F.R.S., V.P.G.S., is now (1869) Lecturer on Mining and Mineralogy at the Royal School of Mines; and Inspector of the Mineral Property of the Crown and the Duchy of Cornwall.

His Lecture "*On the Value of an extended knowledge of Mineralogy and the Processes of Mining,* was delivered in 1852.

It may not be out of place to recapitulate that

D. Borlase	states	Yellow copper-ore	to have been thrown away as rubbish; but is silent as to ..	Black & vitreous ore	having been treated in the same manner.
Dr. Pryce		Black ,,		Yellow & vitreous ,,	
Mr. Smyth		Vitreous ,,		Yellow & black ,,	

Now—

Dr. Borlase was born in 1695, and in 1758 he wrote that "about sixty years earlier yellow ore was thrown away;" it is manifest, therefore, that when such waste took place, he (the future writer) was yet in his childhood;—

Dr. Pryce — whose birth took place about 1720-1730 — stated in 1778 that "seventy years before the Tinners threw black-ore into the brooks as refuse;" a comparison of dates proves that period of ignorance to have existed when he (who has perpetuated the remembrance of it) was as yet unborn; even the separation of copper from calcined matter, which had been already treated for the

and in the neighbourhood, and some of them have

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tin-ore it contained, seems to have first taken place in 1735, during his infancy;—and Mr. Smyth (an occasional, though now a frequent, visitor to the neighbourhood)—speaking, in 1852, more than one hundred years after the event he describes—says "at the commencement of the last century Redruthite (vitreous-copper) was thrown as worthless rubbish over the cliffs of St. Just into the Atlantic;" at that time, however, Mr. (afterwards Dr.) Borlase—a native of the parish—resided on or near the spot.

Mr. Phillips—who was born in 1773—recorded it in 1814 as "an undoubted fact that * * * within a century * * * many roads in the county were mended with copper-ore;" the event being thus—in another instance—supposed to have taken place before the birth of the describer.

These several writers, therefore, record—

differences (though perhaps immaterial ones) } as to the periods of misappropriation;—
,, ,, in the natures of the ores misappropriated;—and
,, ,, ,, modes of their misappropriation;

nor is it surprizing that accounts should so materially differ, when given so long after the events, by parties who could not have been eye-witnesses.

But the early progress of copper-mining in Cornwall had not escaped the notice of contemporary authors;—for—

Mr. Carew states that [not later than 1602] he had visited a copper-mine, the produce of which shipped to Wales for reduction.

Mr. Hals—who lived from 1653 to 1737,—and Mr. Tonkin—who was born in 1678 and died in 1742—state that, between 1673 and 1736, the yellow, ash-coloured (grey), earthy-black, and other—less abundant—ores of copper had been—not only recognized—but largely and profitably wrought, both in the eastern and western parts of the county.

It appears, therefore, that Dr. Borlase, in 1758, sixty, and Dr. Pryce, in 1778, seventy, years after the events,—which, in fact, must have happened in the childhood of one and during the infancy, if not before the birth, of the other,—represented the workmen, in 1698 and 1708, to have rejected, as worthless, two rich ores of copper; whilst, in 1852, Mr. Smyth reported a third valuable copper-ore to have been—at the commencement of the last century—cast into the sea. Whereas Mr. Hals and Mr. Tonkin, the latter himself a mine-owner—who lived (and wrote from 1685 to 1733) before, during, and after the periods when, it was (subsequently) said, such ores were "thrown away"—mention the mines then worked in different parts of Cornwall, and describe the nature of their produce, but both are—as (in 1586—1602) their predecessor Mr. Carew had been—silent on the subject of waste.

The circumstance—mentioned by Mr. Taylor—that seven hundred tons of English copper were coined at the mint in 1717, bears directly on this question.

In reference to the statement that copper-ore had, within a century, been used as *road-metal;* it must be remembered that all *lodes* partake, more or less, the nature

been amongst the most productive in the county:

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of the adjoining rocks, and thus consist, in great measure, of earthy minerals.[a] Of the principal Cornish vein-stones and ores the comparative hardness is,—quartz 7·, felspar 6·—6·5, hornblende 5·—6·, fluor 4·, chlorite 2·—2·5, oxide of tin 6·—7·, iron-pyrites 6·—6·5, copper-pprites 3·5—4·, vitreous-copper 2·5—3·, black copper-ore usually occurs in an earthy state. The ores of copper are therefore both softer and less plentiful than the ordinary vein-stones.

Thus all later writers concur in stating much waste to have taken place at the commencement of copper-mining in Cornwall, but they differ as to the kind of ore wasted, and on the mode of the waste; whereas earlier authors are, to a man, silent on the subject.

The following different accounts of the same circumstance may not be irrelevant here.

"Even within these few days a case has occurred in Devonshire where a field wall was constructed of grey copper ore, and the breaking of a gate post led to a knowledge of the fact. This happened in a mining district."

De la Beche, *Inaugural Discourse at the opening of the Government School of Mines,* 6th November, 1851, p. 10, *Note.*

"The stuff brought together, at the spot mentioned, from walls, gate-post, pits, &c., by mining and all other means, was but a few tons; and after the best manipulation—even at a high Standard—it was *unsaleable.*"

Joseph Matthews, Esq., Purser of *Wheal Friendship,* near Tavistock, MSS.

Dr. Pryce states that owing to negligence in *(dressing)* preparing earthy black copper-ore for the market several thousand pounds worth of it had been washed into the rivers and discharged into the [Bristol channel] north sea.

As long as the *lodes* were wrought *underhand*[b]—in fact until 1778-1815,—the water which entered most of, if not all, the shallower works, found its way over the working-*stopes* (steps), to the bottom of the mine. The present system, of *levels* and *winzes,*—by gradually draining the *lode* whilst laying it open for *(back-stopeing)*[c]—prevents, in great measure, the percolation of water through broken ore. But even now, when earthy black copper-ore is wrought—as it was

a "Upon an average for the last ten years (1768—1778) one hundred and fifty thousand tons of rough Lodes have yielded about twenty-four thousand tons (0·16 its weight) of merchantable copper ore."—Pryce, *Mineralogia Cornubiensis,* p. 186.

"Quant au poids totaux des matières extraites, on sera au-dessous de la rèalité en prenant pour chaque tonne de minerai préparé, prêt à vendre :

50 tonnes extraites des mines d'étain ;
3 ,, ,, de cuivre ;
82 ,, ,, de plomb."

Moissenet, *Annales des Mines,* 6me Série, II. p. 252.

b Borlase, *Nat. Hist. of Cornwall,* p. 169, *Pl. XVIII.* Carne, *Cornwall Geol. Trans.* III. pp. 68—9. *Ante,* pp. 645—6, *Sub-note.*

c Carne, *Cornwall Geol, Trans.,* III. pp. 67—72. *Ante,* pp. 645—6, *Sub-note.*

thus—

South Caradon, between the 1st of Jan., 1836, and the 30th of June, 1868,	afforded a profit of		£315,605;*
West Caradon, ...	from 1840 to 1868,	,,	about 110,000, †‡
Marke Valley	,, 1840 ,, 1868,	,,	,, 50,000. § ,

Many other mines|| have been wrought within the

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at *Wheal Jewel* [a] during 1829-31—in a "wet *Country*," the "*weepings*" of the *ends*, *walls*, and *backs* accumulate in the *levels*, flow to the shafts, and are raised through the pumps; bearing with them, in suspension, finer and softer portions of the mineral; which either subside and are recovered (occasionally in receptacles prepared for arresting them) in the *adit*, or pass off in the stream and are lost. Such loss, however, is by no means owing to ignorance of the nature and value of the ore lost; but—like the loss of tin-ore in Cornwall, [b] and of gold (where the vein-stones are *stamped)* in Brazil [c]—is due to the, insufficient, means hitherto adopted for intercepting it.

* *South Caradon,* from the 1st of January, 1836, to the 30th of June, 1868, afforded ores which realized } £1,128,595

the working expenses (salaries, wages, tools, &c.) during the same period amounted to	£750,067	
Royalties *(Dues)*	62,923	
Profits	315,605	
		£1,128,595

W. H. Rule, Esq., Purser and Accountant of the Mine, MSS. *Ante,* p. 457; *Table XIV.*

† Allen, *History of Liskeard,* pp. 396, 420. Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District,* pp. 34—6, 92—3. Captain William Johns, Manager of *West Caradon,* MSS.

‡ "A striking increase in the value of property occurred with respect to Downhill, a small coarse tenement in St. Cleer, which had been purchased thirty years before for £200 * * * . By the discovery of mineral lodes, and the opening of West Caradon Copper Mine in this barren spot, the proprietors have received for the last twelve years, without any risk, an income of more than £2,000 a year, as dues on the ore. The landowner of South Caradon, an equally barren surface, has benefitted to a still greater extent."

Allen, *History of Liskeard,* p. 397. *Ante,* p. 353.

§ Captain John Truscott, Manager of *Marke Valley,* MSS.

|| In 1862,

East Caradon had already given	£29,952	£37,970 profit;
Craddock Moor ,, ...	8,018	

a Fox, *Phil. Trans.,* cxl. (1830) p. 401. Henwood, *Cornwall Geol. Trans.,* v. *Table LXV.*
b *Ante,* p. 354, Note ‡
c *Ibid,* pp. 354—5.

district, and in its neighbourhood; but the writer has not examined them.

Pebbles of stream-tin ore are, from time to time, still found, amongst the rubbish, on either side of an ancient opening * which extends, from near the Hurlers,† northward to Withy-brook marsh.‡

The low lands traversed by greenstones are exceedingly fertile; but the thin covering of slate, which overlies the granite, affords an ungrateful soil. Undulating moors and impassable swamps occupy

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whilst in

Caradon Consols	£22,712	£195,433 had been expended.
Caradon Hill	1,843	
East Wheal Agar	11,424	
Gonamena	20,121	
Great Caradon	7,782	
New South Caradon	3,000	
North Phœnix	1,100	
South Caradon Wheal Hooper	14,221	
South Phœnix	35,172	
West Rose Down	5,875	
West Sharp Tor	36,608	
Wheal Caradon	5,400	
Wheal Norris	15,175	
Wheal Pollard	15,000	

Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 7, 9.

* De la Beche, *Ordnance Geological Maps*, Sheet xxv. Whitley, *Geological Map of the Caradon Mining District*. Symons, *Plan of the Caradon Mining District*.

† Borlase, *Antiquities, Historical and Monumental, of the County of Cornwall*, p. 199, *Pl. XVII., Fig.* 6.

‡ "On the west side of the Cheesewring a small stream, a mere rivulet, finds its way along a valley extending northward into the moors of Altarnun and Northill; and there are numerous evidences of its course having been worked for tin—probably at periods far apart."

Blight, *Journal of the Royal Institution of Cornwall*, iii. (No. ix.) p. 13.

great part of the granitic region.* Caradon, Sharp Tor, and the picturesque rocks of the Cheese-wring,†

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* "The granite of this district * * * throughout its whole extent is one expanded scene of sterility and desolation: trees there are none; and it is only in favoured spots, that vegetation has attained even to the size of a furze-bush. The elevated situation of this granitic land, exposed to every blast from the ocean, is, without doubt, unpropitious to the growth of trees and shrubs: but a more powerful cause is to be found in the nature of the mass that results from the decomposition of the granite. The grains of quartz render the granitic soil gravelly and easily permeable to water; so that, in all inclined situations, the rain washes away the fine particles of light clay that have been produced by the decay of the felspar; thus rendering the soil less adapted for vegetation, and not sufficiently tenacious to give a firm support to trees. * * * All the hills are crowned, and covered on their precipitous sides with immense hoary blocks of granite, which are generally heaped upon each other in the most fantastic forms. * * * The bottoms of all the valleys are covered with bogs, which are sometimes so extensive and deep, and have such long and winding branches, that, even in fine weather, it is difficult for a stranger to extricate himself, when once entangled in their mazes. In many places, the bog is more than a dozen feet in depth: the bottom layers of which, afford a good peat, not inferior to that of Ireland."—Boase, *Cornwall Geol. Trans.*, iv. p. 170.

† In course of the Trigonometrical Survey "Caraton Hill" was ascertained to be .... 1,208 feet above the level of the sea.
During the Geological Survey "Sharp Point Tor" was found to be .... } 1,200 " " .

De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, pp. 14, 18.

"The Rock now called Wringcheese attracts the admiration of all Travellers. * * * The upperstone was, as I have been informed, a Logan or Rocking-stone, and might, when it was entire, be easily moved with a pole; but part of it has been broken off, and that weight which kept it on poise is taken away. The whole heap of stone is 32 feet high; the great weight of the upper part, and the slenderness of the under part makes every one wonder how such an ill-grounded pile could resist for so many ages the storms of such an exposed situation. * * * There are several heaps of Stones on the same hill, and also on a hill about a mile distant, called Kell-mar'r, of like fabrick though not near so high as this."
Borlase, *Antiquities of Cornwall* (Second Edition), p. 173, *Pl. XII. Fig.* 1.

"This remarkable cairn consists of five stones, of which the upper ones are so much the largest as to overhang the base on all sides. The collective height of the whole pile is about 15 feet."
Mac Culloch, *Geol. Trans.*, ii. p. 70, *Pl. IV.*

"This remarkable mass of rocks, eight or ten in number, is about 22 feet in

however, attain an elevation of twelve hundred feet, and command a prospect of great extent, variety, and beauty.*

The following columns show the produce of the several copper-mines described, and the numbers of work-people employed, as well as the power of the steam and water machinery in use, at each of them respectively, during the year 1851.

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height; at the broadest place near the top about thirty-four feet in diameter; and at the narrowest part of the base about 17 feet."

Parochial History of Cornwall (Truro, 1869), III. p. 132.

Hitchins & Drew, *History of Cornwall*, I. p. 144; II. p. 420. Lysons, *Cornwall*, p. CLXXXIV. C. S. Gilbert, *Historical Survey of Cornwall*, I. p. 172; II. p. 479. Bond, *History of Looe*, p. 204.

* "The views from Sharp-Tor are truly sublime. The spot is nearly the centre of the broadest part of the County; from it we saw both seas, north and south, and consequently the intervening land, * * *. We also saw in the north sea a very high land, which we concluded must be Lundy island; * * *. The prospect was equally extensive east and west. We discovered Launceston castle, * * * and we were much struck with the beautiful and highly cultivated lands to the east, terminated in part by the high lands of Dartmoor. To the westward nothing was to be seen but a vast continuance of moor land, without a hedge, without a tree, for a stretch of many miles. The extreme point of our western view, dimmed by distance, showed us Roach rock, and we also saw Dosmerry about four or five miles off; our south view commanded Plymouth-sound, and a long extent of coast and sea."

Bond, *History of Looe*, pp. 208—9.

"The scene from the Cheesewring, at an elevation of upwards of twelve hundred feet, is of a most imposing character. To the west all is rough and wild, a large succession of hills with Brown Willy and Rough Tor from their height and broken surface forcing themselves into foremost attention. Here the stern grandeur of the moor is seen to perfection. Looking south the prospect is more pleasing. Immediately beneath us are the granite works, with their cone-like heap of rubble; and just beyond, occupying twenty acres of ground, is a row of cottages with gardens occupied by the quarrymen. Further on are the Caradon and Phœnix mines; and then commences that fertile and well-wooded district between Liskeard and Looe, the sea forming the horizon. The coast of the English Channel is to be seen from Rame Head to Fowey; turning to the east Kithill and Dartmoor come into the view; * * * and towards the north Hartland Point and Barnstable Bay—some thirty or forty miles off [are plainly seen.]"—*Western Daily Mercury*, XV. (No. 2,463, 28th May, 1868), p. 2.

Copper-ore obtained, Population employed, and Machinery in use, at the principal Mines in the Caradon District, during the year 1851.

Mines.	Copper-ore.		Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores and working stamping.mills.			Water-wheels.	
	Tons of 21 cwt.	Value.	Men	Women	Children	Totals	Diameter of cylinder. Inches	Stroke in cylinder. Feet	Stroke in pump. Feet	Diameter of cylinder. Inches	Stroke in cylinder. Feet.	Stroke at crank end of beam. Feet	Diameter. Feet	Width in breast. Feet
		£								30^{d}	...	...	...	...
West Caradon .	4,128*	£30,330*	363	83	107	553	30	7	7·	22^{s}	...	...	...	...
										20^{s}	...	...	...	...
							45	9	8·	26^{s}	9	9	...	...
South Caradon.	2,818*	20,208*	320	36	54	410	40	9	9·	16^{c} 30^{c}	9	9	...	...
							30	...	...	...	...	...	...	...
Phœnix	962*	10,502*	120	6	6	132	36	9	6·5	18^{d}	9	9	40 20	2· 3·
Marke Valley...	1,701*	5,924*	70	30	20	120	36	9	8·	...	...	...	40 20	2· 2·5
Trethevy	..	...	34	...	...	34	45	9	8·	...	...	...	34	3·
Totals	9,609	66,964	907	155	187	1,249	7	...	...	6	...	...	5	...

* Hunt, *Records of the School of Mines*, I. p. 447. *d.* Double-acting engines. *s.* Single-acting engines. *c.* Combined (Hornblower's) engines.

Lead-mines have been wrought to great depth, extent, and advantage in Menheniot some two miles and a half N.N.E., as well as in Lanreath and Saint Pinnock three miles and a half S.W., of Liskeard.*

The Menheniot District

extends from Butterdon, near the Liskeard and Callington turnpike (about two miles and a half S.E. of the Caradon granite †) S., to within half-a-mile of the church; a tract, perhaps a mile and a half in length, but nowhere exceeding two furlongs in width.

Hitherto the only productive part of

The Lanreath and Saint Pinnock District

has been an area of scarcely a mile long or a furlong wide, near the confluence of several rivulets with the Duloe ‡ brook at *Herod's-foot.*§

As the characters of the rocks, *lodes*, and *cross-*

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* "Herod's-foot is situated in the boundary of the parishes of St. Pinnock and Lanreath, about seven miles S.W. of Caradon; Trelawny in Menheniot, from four to five miles E. of that hill."

Giles, *Cornwall Geol. Trans.*, vii. p. 201.

"The lead mining district in the neighbourhood of Liskeard * * * is rather scattered, extending in the killas in a zone about 8 miles long, from 4 miles E.N.E of Liskeard to about the same distance S.W. of that town, flanking on the south of the Caradon granite at a distance varying from 2½ to 5 miles."

Salmon, *Mining and Smelting Magazine*, ii. p. 211.

† *Ordnance Geological Maps*, Sheet xxv. *Ante*, p. 656.

‡ "The Duloe rises at Broadoak Common, St. Pinnock, and joins the Looe near its mouth."—*Pick and Gad* (1857), p. 6.

§ "Herod's-foot, the oldest mining work in the neighbourhood of Liskeard, is rather curiously situated at the confluence of four steep valleys, through the principal of which the river Duloe flows nearly due north and south to its junction with the Looe."—Salmon, *Mining and Smelting Magazine*, ii. p. 211.

veins, and the relations they severally bear to one another, are—with a single exception—much the same in Menheniot as in the Lanreath and Saint Pinnock district, it may be convenient to consider them at the same time.

(*a*) The rocks in both districts consist mostly of slates; generally greenish, brown, drab, or dun-coloured near the surface, but homogeneous, of silky lustre, and of deep-blue or blackish hue at greater depths.

Certain nests of pulverulent ferruginous matter (? of organic origin) interlie the slates in a shallow quarry near the boundary between *Wheal Trelawny* and *Wheal Mary Ann*;* and similar bodies, as well as *Crinoideal* remains, occur on the way-side near *Herod's-foot*.*

* "At Roseland * * * organisms are very numerous, though generally in a broken imperfect condition; they consist of *Trilobites*, *Orthocerites*, *Bellerophons*, *Turbinolopses*. *Pleurodictya problematica*, and *Crinoidea*, besides other forms which I have not been able to identify. * * *

"At Stoney-bridge * * * two or three examinations rewarded me with several portions of *Trilobites* and some *Turbinolopses*, and also what I take to be a *Spirifer*. * * *

"At Trussil-bridge the fossils are, if not exclusively, yet mostly found in certain thin strata here and there along the succession of the beds; but the strata in which the organic remains most abound differ from the general sample in being softer and more ferruginous."

Giles, *Cornwall Geol. Trans.*, vii. (1849—51), pp. 94—5, 97, 170.

"I could trace *Crinoidea*, &c. in the slates, all the way from Lamellion by Herod's Foot, Berry Down, and Lanreath, to St. Veep."

Peach, *Cornwall Geol. Trans.*, vii. (1849), p. 104.

"The beds near Liskeard are considerably lower [than the Plymouth limestone] in the series of deposits: and it was not without hesitation that I designated them by the distinctive name of *Liskeard Group*. They are certainly neither Silurian nor Cambrian, and may be regarded as a lower subdivision of the Great Plymouth Group. * * * A very old Devonian group with many fossils, collected and partly described by Mr. Giles and Mr. Peach, exists in the neighbourhood of Liskeard."—Sedgwick, *Quarterly Journal of the Geol. Soc.*,

At different depths, on one side or other, and occasionally on both sides, of the *lode*, in various parts of its range through *Wheal Trelawny** and *Wheal Mary Ann*,† as well as, in one part at least, adjoining the *flucan* in the latter, the ordinary homogeneous clay-slate is interlaid by conformable beds and isolated bodies of felspathic and hornblendic rocks ‡ (locally known as *Elvans* §); mostly of massive, but here and

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VIII. (1852), pp. 5, 17, 146; *British Palæozoic Rocks* (Introduction, 1855), pp. XXIII.

"The beds which dip into the synclinal area of Liskeard, and undulate thence to Saltash and St. Stephen's represent in less force the higher group of Davidstow and Lewannick. Folded in among this upper group are some slate-beds locally fossiliferous, as at the Tregril slate-quarry, at Great Tressell north of St. Keyne, Doubleboys, Stoney Bridge, near Liskeard, and in the cuttings of the railway south of that town, and likewise at Saltash and St. Stephen's. Among these fossils we find noticed *Pleurodictyum problematicum*, *Atrypa desquamata*, *Bellerophon bisulcatus*, *Fenestrella antiqua*, an *Orthoceras*, two species of *Spirifera*, some undetermined *Cyathophyillidæ*, *Phacops latifrons*, and *P. punctatus*. The last species was found at Great Tressell by Mr. Pengelly, and is a characteristic Middle-Devonian fossil."

HOLL, *Quarterly Journal of the Geol. Society*, XXIV. (1868), p. 423.

* *Table XXVII.*

† *Table XXVIII.*

‡ "Near Tregerla slate-quarry, the hornblende rock of St. Clere Down, and the same in a state of decomposition, occur in great abundance."

ROGERS, *Cornwall Geol. Trans.*, II. p. 221.

"From Hessen Ford to Quethiock a mixture of arenaceous beds and argillaceous slates [is] traversed, among which we find a great variety of trappean rocks, some of them possessing the schistose character, * * * the compact kinds are generally greenstones."—DE LA BECHE, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 79.

§ "Near the north and south lead lodes [the rocks locally] called elvan consists chiefly either of soft felspar, with more or less of hornblende matter, or of a kind intermediate between the common grey elvan and magnesian greenstone. * * * They do not occur in regular dykes or *courses* (excepting in one instance) but in *floors*, and in numerous small detached masses, called by the miners *bunches*. Many of these appear to be completely isolated; for instance, several masses of this description occurred in the Trelawny shaft so entirely surrounded by killas, as to exhibit slate in all the four corners. But the more general mode of the connexion of the elvan with the lode is in *floors*, of varying,

there of schistose,* structure. Between these and the slate a gradual transition sometimes takes place; but usually the passage from one to the other is distinct and immediate. They are probably connected with one or other of several similar masses, shown on the Ordnance Geological Map;† in one of which—at Lambest—spheroidal bodies, made up of many concentric layers,‡ are imbedded in a basis of identical composition.

Nor is this concretionary structure peculiar to the felspathic and hornblendic rocks, for one side *(wall)* of the *lode*, at a depth of fifty-five fathoms, in *Wheal Trelawny* § presents a section of a spheroidal concretion (*Fig.* 32), presenting a nucleus and an external envelope of galena separated by four several layers of quartz, each distinguishable, from either of the layers adjoining it, by some peculiarity of structure or of hue. This remarkable body was found imbedded in quartz transfused with slaty matter, which gradually shaded into the ordinary deep-blue *(Country)* slate.

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but never of very great, thickness. Their underlie is not conformable to the dip of the slates, but inclines in different directions. * * * In the southern part of Wheal Mary Ann an elvan of a more dyke-like character occurs; * * * but its dip and bearing are alike unknown, although, as nearly as can be judged, [it seems to] dip about S.E."

Giles, *Cornwall Geol. Trans.*, vii. pp. 201,—5,—6. (Abridged.)

* "From Pengover to Clicker Tor the * * * rock exposed is hornblende slate."—Boase, *Cornwall Geol. Trans.*, iv. p. 211.

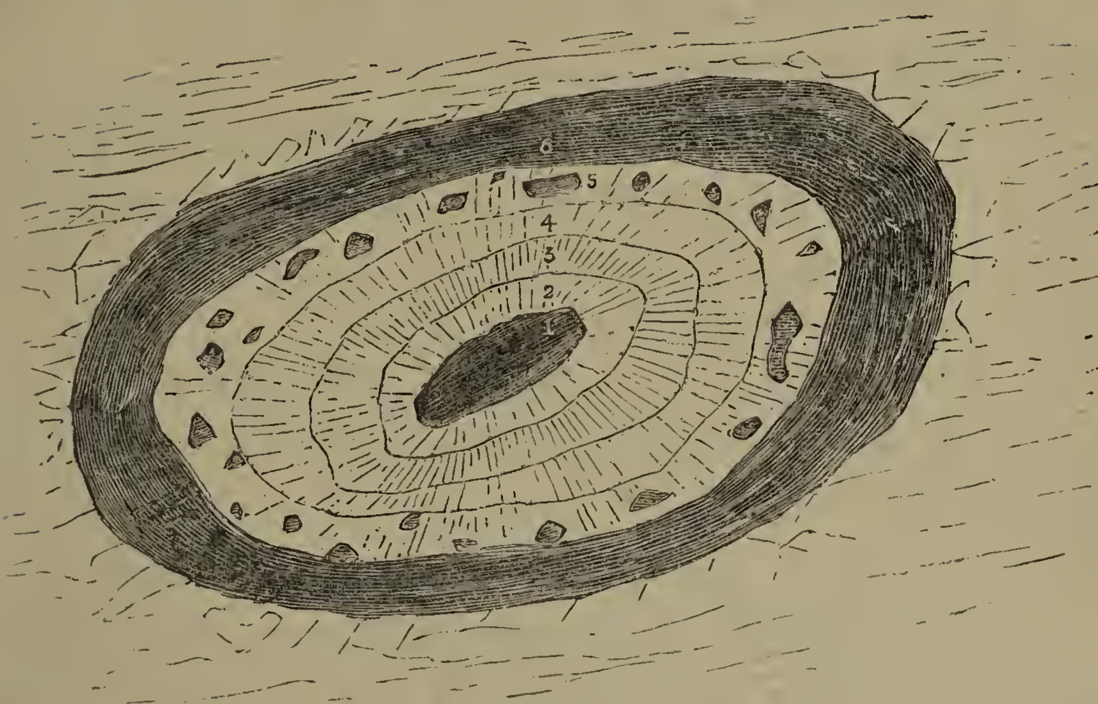
† Sheet xxv.

‡ "It is not improbable that the spheroidal forms so commonly exhibited by the crystalline rocks, are varieties of original structure, the result of some peculiar mode in which their integrant particles have been aggregated together, and which appear to subsist in the same mass, in conjunction with various cuboidal and prismatic arrangements."—Boase, *Primary Geology*, p. 97.

§ *Table XXVII*, column 5.

Fig. 32. *WHEAL TRELAWNY,* EAST CORNWALL.

Section of a concretion in the *(Country)* slate.



(Scale one-fourth of the natural size.)

1. Galena.
2. Quartz; translucent, of slightly radiated structure.
3. ,, : milk-white, ,, ,, ,, .
4. ,, ; translucent, ,, ,, ,, .
5. ,, ; yellowish, containing cavities lined with minute crystals of translucent quartz.
6. Galena.

In both districts the planes of cleavage range from E.—W. to N.E.—S.W., and dip 5°—15° S.—S.E.; in short, occasional, flexures, however, they sometimes decline slightly towards the N.—N.W.

The best developed and most numerous of the joints —maintaining in both cases a general parallelism with the *lodes*—bear from 8° E. of N.—W. of S.* to 12° W. of N.—E. of S.†

Many joints range ,, 25°*—45°‡ E. of N.—W. of S ,
as well as ,, 18°‡—35°* W. of N.—E. of S.,
and others take yet different directions.§

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* *Table XXVIII.*

† "In 1840 the magnetic declination was 25° W."
SABINE, *Phil. Trans.*, CXXXIX. p. 205, *Pl. XIV.* *Ante*, p. 673.

‡ *Table XXIX.*

§ De la Beche, *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 273. *Ante*, p. 673, Note *.

(*b*) Both districts have been carefully examined; but in neither of them has more than one *lode** yet been found productive.

(—1) The *lode* in the mines of Menheniot†‡ takes slightly different directions in different parts of its course; thus in

Wheal Trelawny it bears about 5° W. of N.—E. of S.; but in
Wheal Mary Ann „ 3°—8° E. of N.—W. of S.;

whilst in the Lanreath and Saint Pinnock district,‡ the *lode* at

Herod's-foot bears, generally, 8°—12° W. of N.—E. of S.

(—2) The *lodes* of the entire region maintain an average underlie of 79°; yet in one of them certain portions dip only 64°, and in the other but 70°; of both, however, large parts are nearly vertical. Their general inclination is to the E.; § but—as well in one

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* Henwood, *Reports of the Royal Institution of Cornwall*, XXXIII. (1851), p. 39. Giles, *Cornwall Geol. Trans.*, VII. (1852), pp. 201,—3. Allen, *History of Liskeard*, p. 421. Salmon, *Mining and Smelting Magazine*, II. (1862), pp. 215,—18. Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 17, 26, 37.

† "*Wheal Trelawny*, *Wheal Trehane*, and *Wheal Mary Ann* contain but one *lode* [which bears] about north and south."

Henwood, *Reports of the Royal Institution of Cornwall*, XXXIII. p. 40.

"In Wheal Mary Ann the general bearing } of the lode is 24° or 25° west of south [magnetic].
"In Wheal Trelawny the average bearing } „ is from 19° to 24° east of north „ ."

Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 27, 37.

‡ "In the Herod's-foot and Trelawny mines the vein * * * bears from 20° to 27° E. of N. [magnetic]."—Giles, *Cornwall Geol. Trans.*, VII. pp. 301—2.

"The lodes which produce lead-ore in a zone * * * from 4 miles E.N.E. of Liskeard to about the same distance S.W. of that town * * * have an approximate bearing of north and south."

Salmon, *Mining and Smelting Magazine*, II. p. 211.

§ In the Caradon district every *cross-course* dips towards the W.—*Ante*, p. 682.

as in the other—short flexures towards the W. occur at intervals.

(3—) In width they vary from 0·5 foot to 4 feet; and average, perhaps, 2 feet;* but, occasionally, both are made up of many subordinate veins.

(—4) Of both *lodes* the chief ingredient is quartz;†

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* Henwood, *Reports of the Royal Institution of Cornwall*, XXXIII. p. 40. Giles, *Cornwall Geol. Transactions*, VII. p. 203. Salmon, *Mining and Smelting Magazine*, II. p. 220. Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 17.

† "In the N. part of *Wheal Trelawny* the *lode* affords, near the surface, much earthy-brown iron-ore and granular quartz; the cavities *(vughs)* in which, as well as the joints in the neighbouring *(Country)* rock, sometimes contain the carbonate of lead. At greater depths, galena, great quantities of iron-pyrites, and smaller proportions of blende, are imbedded in quartz that closely resembles hornstone.

"On either side of the boundary between *Wheal Trelawny* and *Wheal Mary Ann*, shallower portions of the *lode* still yield the carbonate—and occasionally also the phosphate—of lead; beneath, however, the quartz—especially towards the middle of the *lode*—is largely mixed with fluor, yet both contain galena, and both are drusy, but the lead-ore and the cavities occur more frequently in the fluor than in the quartz.

"In the S. part of *Wheal Mary Ann* fluor and quartz still make up the chief part of the *lode*. Occasionally, however, small hollows in the fluor are sprinkled with crystals of the same substance; and these—as well as massive portions of the sides—are frequently encrusted with white, greyish, or yellowish crystals of the sulphate of barytes, overlaid with crystallized iron-pyrites, or studded with small brilliant grains of galena, now and then in unusual crystalline forms; moreover both fluor and barytes—especially the fluor—are sometimes thinly powdered with minute double-pointed crystals of quartz. The fluor rests sometimes on quartz, sometimes on galena; but the sulphate of barytes seldom but on fluor. Most of the rarer crystals, however, have been obtained at less than eighty fathoms deep. A peculiarity of this *lode* is, that even in its most productive parts, the ore occurs in small, unconnected, though rich *bunches*, rather than in one large and continuous vein. In the midst of the fluor, indeed, and occasionally, though more rarely, in the quartz, cubic crystals of galena are isolated in the earthy ingredients. Whether the ore be massive or crystallized, quartz and fluor are the only matrices in which it occurs; and the most perpendicular parts of the *lode* are always the most productive.

"The ordinary quartz, which forms the matrix of the lead-ore, frequently bears rectangular impressions; and the iron-pyrites exhibits here and there casts

often granular and sometimes mixed with earthy brown iron-ore near the surface, but generally massive and of milk-white hue beneath; in the Menheniot *lode*, however, it assumes the character of hornstone in some,

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of hexagonal pyramids; but of the substances by which they were impressed, all traces have disappeared."

Henwood, *Reports of the Royal Institution of Cornwall*, xxxiii. (1851), pp. 40—3. (Abridged.)

"At Herod's-foot the matrix mostly carrying the ore is saccharine-quartz, accompanied here and there by iron-pyrites. Antimony in small quantities is also disseminated through the lode, just below the gossan, and fortunately decreases in the lower levels. Blende in still less quantities has been found. But a rich sulphuret of copper is occasionally found in *bunches* sufficiently large to make a mercantile commodity. These *bunches* often occur in parts of the lode which are richest in galena.

"The Trelawny lode * * * which is richest in its nearest approach to the perpendicular, * * * mostly [consists of] a whitish-brown fluor-spar, which contains the ore in a state of general dispersion. Many of the specimens of this mineral which are found on the walls of the fissure, are of various colours and beautifully crystallized in cubes. The beauty of some is enhanced by the presence of very large cubic crystals of galena. Others have small octangular crystals of galena scattered over the fluor. Next to fluor, hornspar is the most plentiful mineral. Small quantities of the carbonate of lead, both crystallized and in the massive state occur, but they are most plentiful in the shallower levels. A few years since a considerable quantity of the phosphate of lead was found just under the gossan, but the miners not placing much value upon it, suffered it to be thrown away with the rubbish: afterwards, if I remember correctly, some few tons of it were collected and sold. But perhaps the most interesting of all the extraneous minerals contained in this lode are the crystals of the sulphuret of barytes; which were abundant to the depth of about forty fathoms, but below that point few have been discovered. * * * It is no uncommon circumstance to meet with slabs exhibiting a coating of pyramidal quartzose crystals over the faces of casts of decomposed minerals. The sulphuret of copper occurs in small quantities in different parts of the lode, and in the deeper parts is so commixed with the galena as to deteriorate some of the samples, although its occurrence is generally coincident with an abundance of ore."

Giles, *Cornwall Geol. Trans.*, vii., pp. 202—5. (Abridged.)

"The lode, which in Wheal Mary Ann and Wheal Trelawny has been remarkable for its productiveness, is a large and strong one containing a great deal of fluor-spar and carbonate of lime, with capels generally on both sides."

Salmon, *Mining and Smelting Magazine*, ii. p. 221.

Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 16, 26, 36.

yet is associated with calcareous matter in other, of the deeper parts. Between the *flucans* in *Wheal Trelawny* and *Wheal Mary Ann*, green, greenish-yellow, or light-brown fluor often prevails towards the middle of the *lode;* but—though frequently abundant—it is seldom, or never, the only vein-stone. White, greyish, or greenish crystals of the sulphate of barytes sprinkle the fluor in many small cavities, to a depth of perhaps eighty fathoms, where—in the S. of *Wheal Mary Ann*—both sides of the *lode* are bounded by rocks of felspar and hornblende. And, under similar circumstances, crystals of quartz are studded with other minerals. At *Herod's-foot* joints in the rock and crevices in the *lode* are often encrusted with pearl-spar.

Iron-pyrites—sometimes associated with silver—is a common ingredient in many, if not in most, parts of both *lodes;* but small quantities of copper-pyrites, and trifling proportions of blende, occur most frequently in,—if indeed they are not limited to,—the quartzose portions of their vein-stones. The sulphuret of antimony and bournonite are peculiar to the *lode* of *Herod's-foot.*

From amongst the earthy brown iron-ore and granular quartz which abound in the shallower parts of both *lodes*, as well as from the joints of the contiguous rocks, small masses and minute crystals of the carbonate, and—less frequently—of the phosphate, of lead, have been obtained at intervals. These salts of lead—which occur near the surface only—are, at greater depths, succeeded by galena. In the Menheniot *lode*—under

certain conditions in the adjoining *(Country)* rock—quartz, fluor, and calcareous matter form a congenial matrix; the ore, however, is more plentiful towards the middle than near the *(walls)* sides; and appears more frequently in single granules, isolated blocks, and small *(bunches)* masses connected by thin veins, than in large *(courses)* bodies of endlong *(shoot)* dip. At *Herod's-foot*, on the other hand, the granular quartzose vein-stone includes numberless small lumps, and is traversed by many thick ribs of ore.

In both these—as in most, if not in all, other—districts the lead-ore obtained from different *lodes*, and indeed from different parts of the same *lode*, are unequally argentiferous.*

The following columns show the proportions of silver obtained from the galena wrought at distant parts of, and at various depths in, the Menheniot *lode*.

Wheal Trelawny.

1851.† Depth 105 fathoms.			1856.‡	1857.§	1869.† Depth 210 fathoms.		
Highest	Lowest	Mean	Mean	Mean	Highest	Lowest	Mean
0·001376	0·001035	0·001245	0·000966	0·001371	0·001516	0·001335	0·001401

* "La galène contient toujours de l'argent, en proportion très-variable, dans les différents filons d'une même localité, et dans les diverses parties d'un même filon." — Rivot, *Principes Généraux du traitement des Minerais Métalliques*, ii. p. 10.

† From *data* supplied by the kindness of Edward Michell, Esq., of Mitchell Hill, near Truro.

‡ Hunt, *Memoirs of the Geological Survey of Great Britain* (Mining Records for 1856), p. 29. *Ante*, p. 120.

§ Hunt, *Memoirs of the Geological Survey of Great Britain* (Mining Records for 1857), p. 31. *Ante*, p. 120.

"Where the galena is associated with copper, it contains an unusually large

Wheal Mary Ann.

1851.* Depth 98 fathoms.			1856.†	1857.‡	1867.* Depth 256 fathoms.		
Highest	Lowest	Mean	Mean	Mean	Highest	Lowest	Mean
0·001545	0·001166	0·001349	0·001168	0·001897	0·001400	0·001224	0·001327

Thus, at *Wheal Trelawny*,

the richest argentiferous galena obtained at a depth of.....	105 fathoms, afforded	0·001376	its weight of of silver.
,, ,,	210§ ,, , ,,	0·001516	,, .

At *Wheal Mary Ann*, on the contrary,

the richest argentiferous galena obtained at a depth of.....	98 fathoms, yielded	0,001545	,, .
,, ,,	256§ ,, , ,,	0,001400	,, .

In both mines, however, the least argentiferous of the ore wrought at the greatest depths§ gave larger proportions of silver than that found nearer the surface.

The lead-ore extracted from different parts of the *Herod's-foot lode* has afforded the undermentioned proportions of silver.

Herod's-foot.

Old, or Northern, Mine. Depth 141 fathoms.		New, or Southern, Mine. Depth 160 fathoms.	
1851.‖	1856.†	1857.‡	1867.¶
Mean	Mean	Mean	Mean
0·000350	0·000359	0·000653	0·001895

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amount of silver. * * * In the hard killas the lode is smaller; but * * * it is here considerably richer in silver (containing from 13 to 17 ounces per ton more) than in any other part of the mine."

GILES, *Cornwall Geol. Trans.*, VII. pp. 205—6.

* *Ante*, p. 708, Note †. † *Ibid*, Note ‡. ‡ *Ibid*, Note §.

§ "The substantial ore ground is entirely in the bottom of the mine."

SALMON, *Mining and Smelting Magazine*, II. p. 218.

‖ Salmon *Mining and Smelting Magazine*, II. p. 214.

¶ Thomas Trevillion, Esq., *Manager and Purser of the Mine*, MS.

Between the proportions of lead and silver, however, there seems no necessary connexion.*

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* "La teneur en argent des gallènes est généralement trop faible pour qu'on puisse déterminer par des moyens chimiques l'état de combinaison du métal précieux; il existe probablement à l'état de sulfure duns la galène."

Rivot, *Principes Généraux du traitement des Minerais Métalliques*, II. p. 11.

At *Wheal Ludcott*, on the confines of Menheniot, about a mile and a half N.N.E. of *Wheal Trelawny*, the *(Country)* rock is homogeneous, glossy, and thick lamellar, dark-blue slate; the planes of its cleavage range nearly N.E.—S.W., and dip 15°—25° S.E.; whilst the joints which intersect it bear 20°—25° W. of N.—E. of S., 20°—25° N. of E.—S. of W., and 40°—45° N. of E.—S. of W. respectively.

Two, nearly parallel, *lodes*, running about N.—S., dipping 80°—86° E., and averaging from two to three feet in width, have been wrought, one to about eighty, the other to more than one hundred and thirty, fathoms in depth. The shallower parts of both consisted of granular quartz, slaty-clay, and earthy brown iron-ore, slightly and irregularly sprinkled with iron-pyrites, copper-pyrites, blende, and galena; but beneath, the quartz assumed some characters of hornstone, calcareous matter appeared, and—at intervals—the *lodes* were rich in galena, which—differing in quality on opposite sides of the N. *cross-vein*,—yielded from 0·000746 to 0·001201 its weight of silver.

Three *cross-veins*, all bearing about E.—W., dipping S. 60°—70°, and measuring usually from one foot to three feet—in one case, however as much as eighteen feet—in width. All three intersect both the *lodes*; but

whilst the southernmost *cross-vein* } *heave* both the *lodes* towards the *right-hand*
and the middle ,, } (R.-R.A.),
,, northernmost ,, *heaves* ,, ,, ,, *left-hand*
(L.-R.A.).

The *cross-veins* consist generally of slaty clay, mixed with granular quartz, calcareous-spar, the carbonate of iron, and iron-pyrites; but, here and there, they contain masses of hornstone-quartz, small quantities of copper-pyrites, and isolated bodies of galena. Between the severed portions of the easternmost *lode*, at a depth of from ninety-three to one hundred and ten fathoms, however, the northern *cross-vein* afforded single crystals of—but slightly argentiferous—galena imbedded in large *bunches* of vitreous silver; crystalline granules, sometimes of ruby silver *(pyrargyrite)*, and yet more frequently of vitreous silver, sprinkling crystals of quartz and of calcareous spar, in numerous small *(vughs)* cavities; and earthy black silver-ore investing as well crystals of galena, as flakes and threads of native silver. This spot yielded 304·7743 tons *(Avoir.)* of, more or less, argentiferous galena; which—ranging in price from £1 : 7 : 6 to (£2 : 14 : 0 per lb.) £6,048 per ton—realized, in 1861—3, £22,501 : 8 : 6.

Salmon, *Mining and Smelting Magazine*, II. pp. 78—83, *Fig.* 2, 3, 4. Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 18—24, *Fig.* 1.

Ante, pp. 120—1, Note.

Rectangular impressions occur on quartz in some,

The following columns—compiled by John Taylor, Esq., Purser of *Wheal Ludcott*, from accounts kept at the mine,—show the quantities of ore obtained from the *northernmost cross-vein*,—proportions of silver and of lead contained in the ore,—the prices at which the several *parcels* were sold,—and the proceeds of each sale.

Date.	Weight (*Av.*) of ore. tons.	cwt.	qrs.	lbs.	Proportions of Silver.	Lead.	Price per (*Av.*) ton. £	s.	d.	Amount. £	s.	d.
1861												
Sept. 27th	2	19	3	0	0·037026	0·202500	290	14	6	868	10	9
,,	9	2	3	0	—	—	47	6	0	431	17	10
Nov. 13th	9	18	0	0	—	—	22	14	3	223	17	6
1862												
Jan. 4th	23	3	3	0	—	—	2	0	6	46	18	8
13th	1	0	0	0	0·073401	0·175000	694	0	0	694	0	0
Feb. 22nd	1	4	2	0	0·067449	0·112500	652	10	0	799	6	3
March 1st	13	5	0	0	0·003265	0·081250	25	7	6	336	4	4
22nd	10	0	0	0	0·000612	—	1	7	6	13	15	0
27th	2	0	0	0	0·048513	0·137500	457	4	0	914	8	0
April 3rd	1	2	0	0	0·025423	0·375000	235	0	0	258	10	0
9th	1	18	2	0	0·033554	0·137500	367	6	6	707	1	10
,,	13	0	1	0	0·004635	0·075000	33	15	0	439	3	0
May 10th	3	10	3	8	0·041866	0·016250	378	0	0	1,338	10	6
June 5th	20	0	2	0	0·004548	—	31	15	0	635	15	10
July 1st	3	14	2	10	0·050146	0·137500	464	0	0	1,730	9	4
,,	3	12	0	0	0·007959	0·400000	80	15	0	290	14	0
Aug. 18th	1	1	1	23	0·095977	0·237500	878	0	0	941	17	9
,,	3	14	1	11	0·039388	0·112500	380	7	0	1,413	18	3
,,	25	4	1	0	0·004373	—	34	2	6	860	7	6
Oct. 6th	3	18	3	22	0·042274	0·131250	382	0	0	1,507	17	6
,,	1	12	1	20	0·018512	0·306250	116	1	6	188	4	0
,,	32	19	1	0	—	—	9	12	0	316	8	9
Nov. 25th	1	0	3	7	0·048338	0·156250	422	10	6	439	13	9
,,	5	7	3	8	0·022158	0·137500	224	10	6	1,210	8	6
,,	23	8	0	0	0·001633	—	10	1	0	235	3	4
1863												
Jan. 5th	7	2	2	0	0·036152	0·137500	343	16	6	2,449	15	0
,,	6	7	1	18	0·006006	0·125000	63	14	6	405	19	2
,,	19	9	3	0	0·001166	—	10	2	6	197	6	2
April 6th	4	11	2	6	0·025423	0·106250	223	9	0	1,022	17	7
,,	3	7	1	21	0·003265	—	35	0	0	118	0	3
,,	21	18	3	0	0·001633	—	9	10	6	208	19	0
,,	0	0	2	27¾	—*a*	—	6,048	0	0*a*	226	2	6
,,	0	0	2	18½	—*b*	—	4,592	0	0*b*	152	14	6
,,	0	0	1	2¼	—*c*	—	4,986	0	0*c*	67	6	1
,,	0	2	3	20	—*d*	—	1,568	0	0*d*	229	12	0
July 13th	4	14	0	0	0·010262	0·150000	93	15	0	440	12	6
,,	18	19	3	0	0·001253	—	7	6	6	139	1	7
Totals ..	304	15	1	26½*e*	....	....	....			£22,501	8	6*e*
Mean ..	....				....	....	£73	16	8			

a £2 : 14 : 0 per lb. (*Avoir.*). *c* £2 : 4 : 6 per lb. (*Avoir.*).
b 2 : 1 : 0 ,, ,, . *d* 0 : 14 : 0 ,, ,, .

e "1861.. 12 tons 2 cwt. 2 qrs. value £1,300 : 8 : 7
1862.. 193 ,, 19 ,, 1 ,, ,, 14,624 : 13 : 9
1863.. 86 ,, 14 ,, 0 ,, ,, 5,658 : 6 : 4
292 ,, 15 ,, 3 ,, ,, £21,583 : 8 : 8"
(HUNT, *Memoirs of the Geol. Survey of Great Britain* (Mineral Statistics), for 1861, p. 40; 1862, p. 30; 1863, p. 45.)

and casts of hexagonal pyramids on iron-pyrites in other, parts of the *lode;* but the substances to which they owe their origin have disappeared.

Many parts of both *lodes* enclose thin *(horses)* slices of rock, which take the same directions and dips as the *branches* on either hand ;* but, at the same time, are of identical composition, and jointed and cleaved uniformly, with the immediately contiguous *(Country)* strata. These included masses are, perhaps, as often sharply defined as they are transfused with siliceous and calcareous matter; in both cases they are occasionally penetrated, from either side, by slender *strings* of the vein-stones.

The metalliferous portions (or *leaders)* are, now and then, separated from the containing *(Country)* rocks on either of, or on both, their sides by bodies of breccia; † in which a nucleus of quartz occasionally

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* " At the 80 fathoms level [in *Wheal Mary Ann*] the lode is divided into two parts, one part runs towards and enters the elvan on the E. side, while the main part of the lode traverses the W. side of it, and still preserves the regular underlie."—Giles, *Cornwall Geol. Trans.*, vii. p. 206.

† " Connected with the [Menheniot] *lode*,—and forming as it were a transition between it and the adjoining rock,—is a mass of angular pieces of slate, cemented by quartz, which is often crystalline, and sometimes presents small cavities lined with minute crystals. This brecciated structure,—locally called *capel* or *cab*,—seldom extends more than four or five feet from the *lodé*,—never contains much lead-ore,—and is rather more common on the western or lower side of the *lode* than on the eastern. The lamination of the schistose portions of this—apparently fragmentary—deposit, approximates, though with some exceptions, that of the contiguous slate-rocks. Contrary to the prevailing opinion respecting a similar structure in copper districts; it is, throughout the lead-mines of the neighbourhood, considered a favourable indication."—Henwood, *Reports of the Royal Institution of Cornwall*, xxxiii. (1851), p. 42.

At Herod's-foot the lode stoped above the 127 fathom level " is exceptionally rich. * * * In one part [the galena is of a large grain not rich for silver,

seems imbedded in slate, but far more frequently—for the most part indeed—angular masses of slate are enveloped in successive—not uncommonly as many as six—accretions of quartz, each distinguished by some peculiarity of arrangement or hue, and all of more or less radiated structure.* These included kernels are of widely different dimensions; many being microscopic,—great numbers measuring less than a quarter of an inch,—but few exceeding two inches. In many cases they are highly siliceous; and thin lines of quartz—at times slightly mixed with either iron-pyrites or galena—intersect or interlie the laminæ. The planes of their cleavage are approximately—but not always exactly—parallel; of jointed arrangement they afford no trace. Small cavities, studded with

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but [within a short distance] it suddenly changes to a very fine grained ore highly argentiferous, making in a brecciated lode, very similar altogether to the rich lead ore found in the Goginan district in Cardiganshire. * * *

"At Wheal Mary Ann the lode south from Pollard's shaft at the 172 [fathom level] consists of $1\frac{1}{2}$ feet wide of *capels* and 1 foot of fluor-spar with a little carbonate of lime. * * * North of Pollard's [at the same level] the lode is 4 feet wide composed of carbonate of lime and fluor-spar worth 6 cwt. of ore per fathom, with 2 feet of *capels* on the west side."

SALMON, *Mining and Smelting Magazine*, II. pp 215,—21.

* "When the forces of cohesion and adhesion are nearly balanced, as in saturated solutions, very slight causes may occasion the cohesion to preponderate; and when once this force has been set in action, its influence spreads rapidly throughout the mass. * * * Thus, the dropping in of a similar crystal, the insertion of a thread, or of a wire, or of a piece of stick, if not sufficient to cause sudden crystallization, will generally determine the spot upon which the crystals are first formed, especially if the foreign body or nucleus be rough and irregular in its outline."—MILLER, *Elements of Chemistry*, I. p. 119.

"When a supersaturated saline solution * * * suddenly becomes solid on cooling * * * it will be found that crystallization has been promoted by a minute speck or point at some part of the [containing] tube, and from this point, as from a centre, proceed fine crystalline needles radiating in all directions."

TOMLINSON, *Proceedings of the Royal Society*, XVII. p. 247.

minute botryoidal concretions of agatine structure, encrusted with crystals of quartz, and sprinkled with the carbonate of iron and calcareous spar, occur in all parts of these remarkable deposits.*

Towards the S., in *Wheal Mary Ann*, and throughout *South Wheal Trelawny* which adjoins, as well as between the (N.) old mine and the (S.) new at *Herod's-foot*, the *lodes* are, respectively, represented by mere *bunches* and short, narrow, *strings* of slightly-metalliferous vein-stone.† These mostly follow such joints as maintain the normal directions of the *lodes;* but they rarely affect parallel portions of proximate joints. Wherever such small isolated masses of metal-

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* *Tables XXVII., XXVIII., XXIX.*

† "The nature of the *broken* or *slidy* ground met with in connection with the lead lodes of this district is very remarkable, and well worthy of attention—for it seems to hold all through the district, being equally met with at Mary Ann as at Herodsfoot. The whole strata seem broken up by a succession of disturbances, of a nature between cross-courses and slides. They are generally called *slides* in the district, although they are not slides in the proper meaning of the word as used in West Cornwall; but neither are they exactly cross-courses. This broken ground generally extends for a considerable width, shattering and indeed obliterating the lodes to a great extent; although now and then detached pieces—sometimes rich—are found in it. In Herodsfoot it shortens in depth, as in my experience, I have found to be almost invariably the case in broken channels of ground of this kind. * * * [Under] the hopeful counsels of Captain Trevillion the broken ground has been passed through, and what is to all intents and purposes a new mine has been opened out south. * * *

[At Wheal Mary Ann] "the great run of *slidy* ground which cuts off the lode southward * * * is very similar to the broken ground in Herodsfoot. * * * The first effect on the lode of the approach of this slidy ground is that it is thrown to the right with a bearing W. 45° S. After the slidy ground is intersected the lode is not again seen, although the 110 fathom level has been driven considerably S., E., and W. Some branches were more than once met with, but they soon disappeared again, and for the present the trial is suspended."

SALMON, *Mining and Smelting Magazine,* II. pp. 213–14,—21—2.

Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, pp. 17, 27.

liferous matter occur, they, and the rocks which contain them, are traversed by numberless small *(flucans)* veins of slaty clay. In *Herod's-foot* the works, at different depths, were extended, from thirty to forty-five fathoms, through a deposit of this kind,* before the *lode* which had dwindled, towards the S. in the old mine was recovered in the N. of the new. And at *Wheal Mary Ann* and *South Wheal Trelawny* a still greater distance has been laid open* but, hitherto, without success.

(*c*) The *cross-veins* † observed in this neighbourhood have the undermentioned directions, dips, and dimensions:—

Names.	Directions.	Dips.	Sizes, feet.
Wheal Trelawny flucan	32°—37° S. of E.—N. of W.	S.W. 50°—60°	0 5—1·5
Wheal Mary Ann ,,	22°—28° S. of E.—N. of W.	N.E. 40°—50°	0·2—1·0
Herod's-foot ,,	20°—25° E. of N.—W. of S.	N.W. 50°—60°	3·0—4·0

* At *Herod's-foot* .... this broken ground dipped towards the N.
,, *Wheal Mary Ann* .. ,, ,, S.
SALMON, *Mining & Smelting Magazine*, II. p. 212, *Fig.* 1, p. 219, *Fig.* 2.

† "The [Menheniot] lead-*lode* is intersected by two *flucans;* the northern of them in *Wheal Trelawny* bears about 10° S. of E., and dips S. 50°—60°; the southern of them in *Wheal Mary Ann* bears about S.E. & N.W., and dips N.E. 40°—50°. The *Wheal Trelawny flucan* varies from six to eighteen inches in width, but the *flucan* at *Wheal Mary Ann* seldom attains a breadth of six inches; both consist of clay identical in composition with the rocks in contact; and frequently the *flucans* exhibit traces of schistose structure, exactly corresponding with that of the adjoining slate, of which they are in fact merely softer portions. * * * Thus the *lode* has the direction of the barren veins in other districts, and the *flucans* agree in their bearings,—the one with the *lodes* and the other with the *caunter-lodes* in other parts of Cornwall."
HENWOOD, *Report of the Royal Institution of Cornwall*, XXXIII. pp. 42—3.

"At Wheal Mary Ann the lode in the 172 fathom level is disturbed by a slide which has been seen in the upper levels and dips north."
SALMON, *Mining and Smelting Magazine*, II. p. 220.

"At Trelawny the lode, except where disordered by the slide, of which there are two, is productive throughout a linear distance of 500 fathoms. * * * North of Trehane shaft a slide comes in obliquely, and heaves the lode a little

Thus, whether both series of *lodes* be rich,—as they are at Lake Superior * and at *Bearhaven*;† or the veins of one system be productive and those of the other be barren,—as at *Chalanches* ‡ and throughout Cornwall § generally;—such of them as range transversely and obliquely incline at lower angles, than those which are more nearly parallel, to the meridian.

Where the *cross-veins* of this region traverse beds and masses of felspar and hornblende their chief ingredients are felspathic and hornblendic matter; but when intersecting schistose rocks they consist of slate and slaty-clay, the same planes of cleavage being common to them and to the strata which form their *(walls)* sides. All parts of them are, more or less, spotted and veined with siliceous matter; whilst the laminated portions are also conformably interlaid by thin foliæ of quartz.

The *cross-veins* always intersect the *lodes* they encounter,|| but do not invariably *heave* them either to the same hand ¶ or towards the same angle; thus,—

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to the right."—Webb & Geach, *History and Progress of Mining in the Caradon and Liskeard District*, p. 37.

* *Ante*, p. 408. † *Ibid*, p. 603. ‡ *Ibid*, pp. 526—7.

§ Henwood, *Cornwall Geol. Trans.*, v. pp. 247,—77; *Ante*, pp. 675,—82, 704,—11.

|| "The *Wheal Trelawny flucan heaves* the *lode* different distances (varying from two to twelve feet) at different *levels*, but always towards the left-hand, and to the side of the greater angle; the *Wheal Mary Ann flucan*, which in some places merely divides the *lode* without displacing it, in others *heaves* it about two feet towards the right-hand, and to the side of the smaller angle."

Henwood, *Reports of the Royal Institution of Cornwall*, xxxiii. p. 43.

¶ Thomas, *Survey of the Mining District between Chasewater and Camborne*, p. 22; *Ante*, p. 183, Note †

the *Wheal Trelawny flucan*	*heaves*	the *lode*	to the left-hand,*	and towards the	smaller angle* (L. S.A.)
,, *Wheal Mary Ann* ,,	,,	the same *lode*	,, right- ,, ,*	,,	smaller angle* (R. S.A.)
,, *Herod's-foot* ,,	,,	the *lode*	,, right- ,, ,*	,,	greater angle* (R. G.A.)

Nor are the *heaves* of the same *lode* by the same *cross-vein* uniform at different depths ;† for—

the Menheniot *lode* at its contact with

	the *Wheal Trelawny flucan,*	*Wheal Mary Ann flucan,*
about 30 fms. deep is	*heaved* 12 feet,	—
,, 50 ,, ,,	,, 10 ,, ,	—
,, 55 ,, ,,	,, 2 ,, ;	—
,, 76 ,, ,,	— ...	is *heaved* 3 feet,
,, 88 ,, ,,	— ...	,, simply intersected.

Moreover, the deeper part of the *lode* at *Wheal Trelawny* is intersected by at least one *cross-vein* which has not been recognized near the surface.‡

At *Wheal Mary Ann,* water drawn from the mine, deposits in the steam-boilers troublesomely large incrustations of the sulphate of lime.§

From *Wheal Trelawny* on the N., and *Wheal Mary Ann* on the S., the ground slopes gently to a broad, shallow valley, which crosses the *lode* at nearly right-

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* Henwood, *Cornwall Geol. Trans.*, v. pp. 316—28.

† *Ibid*, pp. 306—14. *Ante,* p. 685.

‡ "In *West Wheal Virgin, Poldory,* and *Wheal Squire* innumerable small *flucans* extend but a few fathoms in either direction, and occasion, as it were rents in the middle of the *lodes*, but neither rise to the surface, nor descend to very great depths. Their results may be compared to rents in the middle, but which do not reach to the edges, of a piece of cloth.—"Henwood, *Cornwall Geol. Trans.,* iii. p. 329; v. pp. 89, 381. *Ante,* pp. 226,—87.

§ "At *Botallack* eels thrive as well in pools *(sinks)* underground as in the stream pumped out of the mine into the engine-pond at the surface; in both cases, however, the water may possibly be more highly charged with sea, than

angles.* At *Herod's-foot*, on the contrary, the *lode* runs nearly parallel to the valley of the Duloe, though at considerable angles to some of its tributary glens.

When the Ordnance Geological Survey was made (in 1839) the mineral riches of Menheniot were as yet unknown.

The produce of the several mines and the numbers of work-people employed, as well as the power of the steam and water machinery in use, at each of them respectively in the year 1851, are shown on a subsequent page.

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with metallic, salt."— STEPHEN HARVEY JAMES, ESQ., *Purser* of the Mine, MS. *Ante*. pp. 354—5, 539, Note *.

* "The surfaces of many of the most productive mines are intersected by depressions. * * * The directions of these sometimes coincide with those of the *lodes*, as at *Godolphin*, *the Consolidated Mines*, *East Crennis*, &c.; but they rather more frequently form considerable but varying angles, as in *Herland*, *Dolcoath*, *Wheal Tolgus*, *Wheal Towan*, *Wheal Leisure*, *Wheal Friendship*, &c."
HENWOOD, *Cornwall Geol. Trans.*, v. (1843), p. 233.

"The forms of the Cornish hills and valleys have originated in a great measure from the structure of the rocks."—BOASE, *Ibid*, IV. p. 432.

"From St. Levan to Ludgvan the courses of thirty valleys on the south coast and of eighteen on the north coast * * * run in the direction of the joints. * * * We may therefore, with much probability, infer that the valleys have been formed along the line of joints, and that the joints existed before the valleys were excavated: thus, the joints governed the direction of the early water-courses, —became enlarged to ravines,—and then to open valleys."
WHITLEY, *Ibid*, VII. p. 350.

"A marked feature in the ore-bearing district of [Breage] is the peculiar system of valley-formations * * * but nowhere is it more plainly seen than at Wheal Vor. The figure of the valley is that of a main trunk with lateral branches having definite rounded terminations, and each having had a small streamlet fed by a spring issuing near its extremity. Near the summit of these hollows, the outcrop of the mineralized portion of the productive lodes has been found."—FRANCIS, *Reports of the Royal Cornwall Polytechnic Society*, XXXVI. (1868), p. 20.

From 1844 to 1868—9 the undermentioned profits have been made in the district; viz.—

at *Wheal Trelawny* *	£56,914
Wheal Mary Ann †	65,585
Herod's-foot ‡	49,848
	£172,347

As the mines are wrought in a rich agricultural district, heaps of rubbish from them abut on some of the most fertile and best cultivated land in Cornwall.

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* *Wheal Trelawny*,

from the 1st of April, 1844, to ,, 26th ,, Nov., 1868, } produced ores which realized.... £464,981,
and afforded a profit of .... 56,914.

James Cock, Esq., *Purser* and *Accountant of the Mine*, MSS.

† *Wheal Mary Ann*,

from the 1st of May, 1846, to ,, 30th ,, Sept., 1868, } yielded ores which were sold for.. £454,788

During which period the working-expenses (salaries, wages, tools, &c.) amounted to			£353,105	
,,	Royalties *(Dues)*	,,	36,098	
,,	Profits	,,	65,585	
				£454,788

W. G. Nettle, Esq., *Purser* and *Accountant* of the Mine, MSS.

‡ *Herod's-foot*,

from the 1st of Nov., 1847, to ,, 31st ,, Oct., 1859,	gave a profit of about	....	£3,000
from ,, 1st of Nov., 1859, to ,, 23rd ,, April, 1869,	,, ,,	....	46,848
			£ 49,848

Thomas Trevillion, Esq., *Manager* and *Purser* of the Mine, MSS.

At *Ludcott & Wrey Consolidated Mines (Ante,* p. 710),

from 1852 to 1865 the amount of capital expended was........	£21,388
,, ,, the lead and silver ores obtained were sold for	101,298
	£122,686

During which period the salaries and wages amounted to			£63,835	
,,	tools & machinery	,,	37,749	
,,	Royalties *(Dues)*	,,	8,022	
,,	Profit divided amongst the shareholders ..	,,	13,080	£122,686

John Taylor, Esq., *Purser* of the Mines, MSS.

Lead-ore obtained, Population employed, and Machinery in use, at the principal Mines in the Menheniot, Lanreath, and Saint Pinnock Districts, during the year 1851.

Mines.	Lead-ore.		Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores and working stamping-mills.			Water-wheels.	
	Tons of 21 cwt.	Value	Men	Women	Children	Totals	Diameter of cylinder. Inches	Stroke in cylinder. Feet	Stroke in pump. Feet	Diameter of cylinder. Inches	Stroke in cylinder. Feet.	Stroke at crank end of beam. Feet	Diameter. Feet	Width in breast. Feet
		£												
Wheal Trelawny.	1,112*	20,612 †	258	72	78	408	{ 50· 22·	10· 5·5	10· 5 5	{ 14 d 24 s	5 ...	5 ...	{ 22 22	2· 2·
Wheal Trehane .	414*	7,674												
Wheal Mary Ann	1,265*	20,880 ‡	280	68	74	422	{ 25· 46·	7·	7·	22 s	8	8		
South Trelawny.	..	...	12	...	...	12	24·5	9·	8·					
Herod's-foot	778§	9,333 §	124	43	50	217	45·	9·	8·	22 d	5	5	20	2·5
Totals	3,569	58,499	674	183	202	1,059	6	...	...	4	...	...	3	

* Hunt, *Records of the School of Mines*, I. p. 452.

† James Cock, Esq., *Purser* of *Wheal Trelawny*, MS.

‡ W. G. Nettle, Esq., *Purser* of *Wheal Mary Ann*, MS.

§ Thomas Trevillion, Esq., *Purser & Manager* of *Herod's-foot*, MS.

d. Double-acting engines. *s.* Single-acting engines.

The foregoing pages supply descriptions—in greater or less detail—of more than one hundred and thirty mines, together with comparisons of the conditions under which the various metals and ores occur in them; but—inasmuch as the chief purpose of this enquiry is to render the experience gained in one country practically useful in another—theoretical speculations have been cautiously avoided.

That important parts of many mines have not been described, and that various questions of interest have not been followed to their solution, is owing to no disregard of one or other; but that the ruinous condition of ancient works or the want of exploratory operations in the former case, and the necessity for considering economic, rather than abstract, subjects in the latter, have narrowed the field of enquiry.

Frequent references have been made to the observations of earlier labourers* in the same—and other similar—districts; these, however, have been sometimes abridged; but in every such case scrupulous care has been taken to preserve the exact purport of the original.†

Notwithstanding certain subjects treated of are but slightly, if they are at all, connected with geological

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* Of these important statements a few were unfortunately overlooked during the preparation of parts of the work to which they would have been most appropriately quoted: in most, if not in all, such instances, however, they have been subsequently introduced, where—though less apposite—they will still be found illustrative.

† All foreign weights and measures have been reduced to their English equivalents.

research, the relations they bear to the history, progress, and economy of Mining, may, perhaps, account for their appearance here.

I now offer my grateful acknowledgements to the Noblemen and Gentlemen who have afforded me opportunity for examining the mines I have attempted to describe; and my warmest thanks to the Mine-Agents, Miners, and other friends, to whose kind assistance and judicious advice I have been, on every occasion, so greatly indebted. My obligations to some have been far greater than to others;—but I fear to particularize any, lest—by unintentional omissions—I may give pain to some who most deserve my gratitude.

W. J. HENWOOD,

3, Clarence Place, Penzance,
1858, November 16th.
1869, October 23rd.

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